S K Mondal's

Machine Design

GATE, IES & IAS 20 Years Question Answers

Contents

Er. S K Mondal

IES Officer (Railway), GATE topper, NTPC ET-2003 batch, 12 years teaching experienced, Author of Hydro Power Familiarization (NTPC Ltd)

Note

If you think there should be a change in option, don't change it by yourself send me a mail at swapan_mondal_01@yahoo.co.in I will send you complete explanation.

Every effort has been made to see that there are no errors (typographical or otherwise) in the material presented. However, it is still possible that there are a few errors (serious or otherwise). I would be thankful to the readers if they are brought to my attention at the following e-mail address: swapan_mondal_01@yahoo.co.in

S K Mondal

1. Design of Joint

Objective Questions (For GATE, IES & IAS)

Previous 20-Years GATE Questions

Keys

GATE-1. Square key of side "d/4" each and length *l* is used to transmit torque "T" from the shaft of diameter "d" to the hub of a pulley. Assuming the length of the key to be equal to the thickness of the pulley, the average shear stress developed in the key is given by [GATE-2003]

(a) $\frac{4T}{ld}$ (b) $\frac{16T}{ld^2}$ (c) $\frac{8T}{ld^2}$ (d) $\frac{16T}{\pi d^3}$

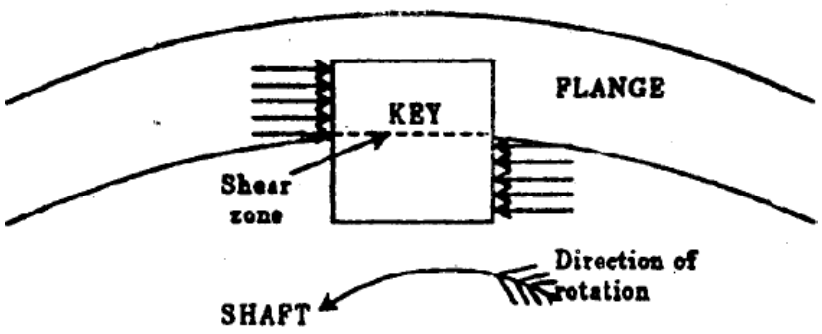
GATE-1. Ans. (c) If a square key of sides d/4 is used then. In that case, for shear failure we have $\left(\frac{d}{4}\times l\right)\tau_x \frac{d}{2} = T$

or $\tau_x = \frac{8T}{ld^2}$ [Where τ_x is the yield stress in shear and *l* is the key length.]

GATE-2. A key connecting a flange coupling to a shaft is likely to fail in[GATE-1995]

(a) Shear (b) tension (c) torsion (d) bending

GATE-2. Ans. (a) Shear is the dominant stress on the key



Welded joints

GATE-3. A 60 mm long and 6 mm thick fillet weld carries a steady load of 15 kN along the weld. The shear strength of the weld material is equal to 200 MPa. The factor of safety is [GATE-2006]

(a) 2.4 (b) 3.4 (c) 4.8 (d) 6.8

GATE-3. Ans. (b)

$$\text{Factorofsafety} = \frac{\text{Strength of material}}{\text{Actual load or strength on material}}$$

$$= \frac{200(\text{in MPa})}{\dfrac{15\times10^{3}}{60\times\dfrac{6}{\cos 45^{o}}\times10^{-6}(\text{in MPa})}} \frac{200(\text{in MPa})}{58.91(\text{in MPa})} = 3.4$$

Threaded fasteners

GATE-4. A threaded nut of M16, ISO metric type, having 2 mm pitch with a pitch diameter of 14.701 mm is to be checked for its pitch diameter using two or three numbers of balls or rollers of the following sizes [GATE-2003]

(a) Rollers of 2 mm ϕ (b) Rollers of 1.155 mm ϕ

(c) Balls of 2 mm ϕ (d) Balls of 1.155 mm ϕ

GATE-4. Ans. (b)

Previous 20-Years IES Questions

Cotters

IES-1. Assertion (A): A cotter joint is used to rigidly connect two coaxial rods carrying tensile load.

Reason (R): Taper in the cotter is provided to facilitate its removal when it fails due to shear. **[IES-2008]**

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

IES-1. Ans. (b) A cotter is a flat wedge shaped piece of rectangular cross-section and its width is tapered (either on one side or both sides) from one end to another for an easy adjustment. The taper varies from 1 in 48 to 1 in 24 and it may be increased up to 1 in 8, if a locking device is provided. The locking device may be a taper pin or a set screw used on the lower end of the cotter. The cotter is usually made of mild steel or wrought iron. A cotter joint is a temporary fastening and is used to connect rigidly two co-axial rods or bars which are subjected to axial tensile or compressive forces.

IES-2. Match List I with List II and select the correct answer using the code given below the Lists: [IES 2007]

List I (Application)	**List II (Joint)**
A. Boiler shell	**1. Cotter joint**
B. Marine shaft coupling	**2. Knuckle joint**
C. Crosshead and piston road	**3. Riveted joint**
D. Automobile gear box (gears to shaft)	**4. Splines**
	5. Bolted Joint

Code:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	1	4	2	5	(b)	3	5	1	4
(c)	1	5	2	4	(d)	3	4	1	5

IES-2. Ans. (b)

IES-3. Match List-I (Parts to be joined) with List-II (Type of Joint) and select the correct answer using the code given below: [IES-2006]

List-I	**List -II**

A. Two rods having relative axial motion		1. Pin Joint
B. Strap end of the connecting rod		2. Knuckle Joint
C. Piston rod and cross head		3. Gib and Cotter Joint
D. Links of four-bar chain		4. Cotter Joint

	A	B	C	D		A	B	C	D
(a)	1	3	4	2	(b)	2	4	3	1
(c)	1	4	3	2	(d)	2	3	4	1

IES-3. Ans. (d)

IES-4. **Match List I with List II and select the correct answer.** **[IES-1994]**

List I (Types of joints)	List II (An element of the joint)
A. Riveted joint	1. Pin
B. Welded joint	2. Strap
C. Bolted joint	3. Lock washer
D. Knuckle joint	4. Fillet

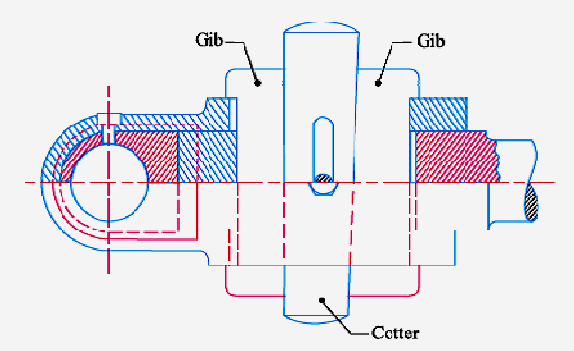
Codes:	A	B	C	D		A	B	C	D
(a)	4	3	2	1	(b)	2	3	4	1
(c)	2	4	3	1	(d)	2	4	1	3

IES-4. Ans. (c)

IES-5. **In a gib and cotter joint, the gib and cotter are subjected to** **[IES-2006]**

(a) Single shear only (b) double shear only
(c) Single shear and crushing (d) double shear and crushing

IES-5. Ans. (d)



IES-6. **Match List I (Items in joints) with List II (Type of failure) and select the correct answer using the codes given below the Lists:** **[IES-2004]**

List I	List II
A. Bolts in bolted joints of engine cylinder cover plate	1.Doubletransverse shear
B. Cotters in cotter joint	2. Torsional shear
C Rivets in lap joints	3 Single transverse shears
D. Bolts holding two flanges in a flange coupling	4. Tension

	A	B	C	D		A	B	C	D
(a)	4	1	3	2	(b)	4	2	3	1
(c)	3	1	4	2	(d)	3	2	4	1

IES-6. Ans. (a)

IES-7. **In a cotter joint, the width of the cotter at the centre is 50 mm and its thickness is 12 mm. The load acting on the cotter is 60 kN. What is the shearing stress developed in the cotter?** **[IES-2004]**

$$\text{Shear stress} = \frac{\text{Load}}{2 \times \text{Area}} = \frac{60 \times 10^3}{2 \times 50 \times 12} = 50 \text{N/mm}^2$$

IES-8. The spigot of a cotter joint has a diameter D and carries a slot for cotter. The permissible crushing stress is x times the permissible tensile stress for the material of spigot where x > 1. The joint carries an axial load P. Which one of the following equations will give the diameter of the spigot? [IES-2001]

(a) $D = 2\sqrt{\frac{P}{\pi\sigma_t}\frac{x-1}{x}}$ (b) $D = 2\sqrt{\frac{P}{\pi\sigma_t}\frac{x+1}{x}}$ (c) $D = \frac{2}{\pi}\sqrt{\frac{P}{\sigma_t}\frac{x+1}{x}}$ (d) $D = \frac{2P}{\pi\sigma_t}\sqrt{x+1}$

IES-8. Ans. (b)

IES-9. Match List-l (Machine element) with List-II (Cause of failure) and select the correct answer using the codes given below the lists: [IES-1998]

List-I	**List-II**
A. Axle	**1. Shear stress**
B. Cotter	**2. Tensile/compressive stress**
C. Connecting rod	**3. Wear**
D. Journal bearing	**4. Bending stress**

Code:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	1	4	2	3	(b)	4	1	2	3
(c)	4	1	3	2	(d)	1	4	3	2

IES-9. Ans. (b)

- In machinery, the general term ***"shaft"*** refers to a member, usually of circular cross-section, which supports gears, sprockets, wheels, rotors, etc., and which is subjected to torsion and to transverse or axial loads acting singly or in combination.
- An ***"axle"*** is a non-rotating member that supports wheels, pulleys, and carries no torque.
- A ***"spindle"*** is a short shaft. Terms such as *line-shaft, head-shaft, stub shaft, transmission shaft, countershaft,* and *flexible shaft* are names associated with special usage.

IES-10. The piston rod and the crosshead in a steam engine are usually connected by means of [IES-2003]

(a) Cotter joint (b) Knuckle joint (c) Ball joint (d) Universal joint

IES-10. Ans. (a)

IES-11. A cotter joint is used when no relative motion is permitted between the rods joined by the cotter. It is capable of transmitting [IES-2002]

(a) Twisting moment (b) an axial tensile as well as compressive load
(c) The bending moment (d) only compressive axial load

IES-11. Ans. (b)

IES-12. Match List I with List II and select the correct answer using the codes given below the lists: [IES-1995]

List I (Different types of detachable joints)	**List II** (Specific use of these detachable joints)
A. Cotter joint	1. Tie rod of a wall crane
B. Knuckle joint	2. Suspension bridges
C. Suspension link joint	3. Diagonal stays in boiler
D. Turn buckle (adjustable joint)	4. Cross-head of a steam engine

Codes:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	4	2	3	1	(b)	4	3	2	1

(c) 3 2 1 4 (d) 2 1 4 3

IES-12. Ans. (a)

IES-13. **Match List I with List II and select the correct answer using the codes given below the lists:** **[IES-1993]**

List I (Type of joint)

A. Cotter joint
B. Knuckle joint
C. Turn buckle
D. Riveted joint

List II (Mode of jointing members)

1. Connects two rods or bars permitting small amount of flexibility
2. Rigidly connects two members
3. Connects two rods having threaded ends
4. Permanent fluid-tight joint between two flat pieces
5. Connects two shafts and transmits torque

Codes:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	5	1	3	2	(b)	2	1	3	4
(c)	5	3	2	4	(d)	2	3	1	4

IES-13. Ans. (b) A cotter is a flat wedge-shaped piece of steel. This is used to connect rigidly two rods which transmit motion in the axial direction, without rotation. These joints may be subjected to tensile or compressive forces along the axes of the rods. Connection of piston rod to the cross-head of a steam engine, valve rod and its stem etc are examples of cotter joint.

IES-14. **Assertion (A):** When the coupler of a turn buckle is turned in one direction both the connecting rods either move closer or move away from each other depending upon the direction of rotation of the coupler. **[IES-1996]**

Reason (R): A turn buckle is used to connect two round rods subjected to tensile loading and requiring subsequent adjustment for tightening or loosening.

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-14. Ans. (b)

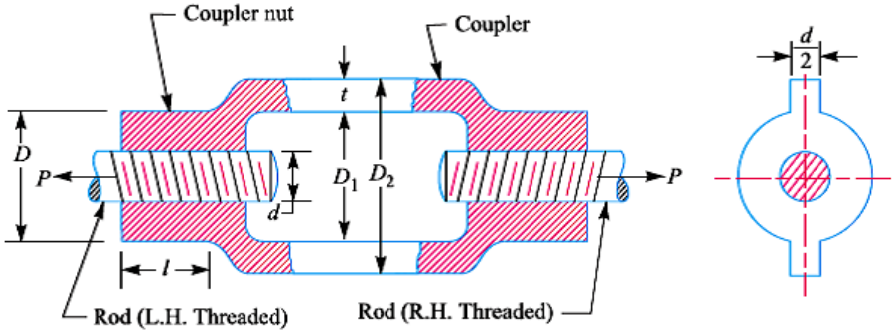


Fig. Turnbuckle

Keys

IES-15. **In the assembly of pulley, key and shaft** **[IES-1993; 1998]**

(c) Key is made the strongest (d) all the three are designed for equal strength

IES-15. **Ans. (b)** Key is made the weakest so that it is cheap and easy to replace in case of failure.

IES-16. **Match List-I (Type of keys) with List-II (Characteristic) and select the correct answer using the codes given below the Lists: [IES-1997]**

List-I	**List-II**
A. Woodruff key	**1. Loose fitting, light duty**
B. Kennedy key	**2. Heavy duty**
C. Feather key	**3. Self-aligning**
D. Flat key	**4. Normal industrial use**

Code:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	2	3	1	4	(b)	3	2	1	4
(c)	2	3	4	1	(d)	3	2	4	1

IES-16. **Ans. (b)** A feather key is used when one component slides over another. The key may be fastened either to the hub or the shaft and the keyway usually has a sliding fit.

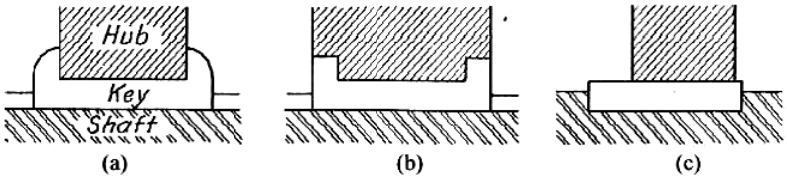


Fig. *feather key*

IES-17. **Match List-I with List-II and select the correct answer using the code given below the lists: [IES-2008]**

List-I (Key/splines)	**List-II (Application)**
A. Gib head key	**1. Self aligning**
B. Woodruff key	**2. Facilitates removal**
C. Parallel key	**3. Mostly used**
D. Splines	**4. Axial movement possible**

Code:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	1	2	3	4	(b)	1	2	4	3
(c)	2	1	3	4	(d)	2	1	4	3

IES-17. Ans. (c)

IES-18. **A spur gear transmitting power is connected to the shaft with a key of rectangular section. The type (s) of stresses developed in the key is fare.**
(a) Shear stress alone (b) bearing stress alone **[IES-1995]**
(c) Both shear and bearing stresses (d) shearing, bearing and bending stresses.

IES-18. Ans. (c) Key develops both shear and bearing stresses.

IES-19. **Assertion (A):** The effect of keyways on a shaft is to reduce its load carrying capacity and to increase its torsional rigidity. **[IES-1994]**
Reason (R): Highly localized stresses occur at or near the corners of keyways.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-19. Ans. (d)

IES-20. **Which key is preferred for the condition where a large amount of impact**

IES-20. Ans. (d)

IES-21. What is sunk key made in the form of a segment of a circular disc of uniform thickness, known as? [IES-2006]
(a) Feather key (b) Kennedy key (c) Woodruff key (d) Saddle key

IES-21. Ans. (c)

IES-22. What are the key functions of a master schedule? [IES-2005]
1. To generate material and capacity requirements
2. To maintain valid priorities
3. An effective capacity utilization
4. Planning the quantity and timing of output over the intermediate time horizons
Select the correct answer using the code given below:
(a) 1, 2 and 3 (b) 2, 3 and 4 (c) 1, 3 and 4 (d) 1, 2 and 4

IES-22. Ans. (b)

IES-23. A square key of side d/4 is to be fitted on a shaft of diameter d and in the hub of a pulley. If the material of the key and shaft is same and the two are to be equally strong in shear, what is the length of the key? [IES-2005]
(a) $\frac{\pi d}{2}$ (b) $\frac{2\pi d}{3}$ (c) $\frac{3\pi d}{4}$ (d) $\frac{4\pi d}{5}$

IES-23. Ans. (a)

IES-24. Which one of the following statements is correct? [IES-2004]
While designing a parallel sunk key it is assumed that the distribution of force along the length of the key
(a) Varies linearly (b) is uniform throughout
(c) varies exponentially, being more at the torque input end
(d) varies exponentially, being less at torque output end

IES-24. Ans. (c) ***Parallel sunk key.*** The parallel sunk keys may be of rectangular or square section uniform in width and thickness throughout. It may be noted that a parallel key is a taperless and is used where the pulley, gear or other mating piece is required to slide along the shaft. In designing a key, forces due to fit of the key are neglected and it is assumed that the distribution of forces along the length of key is uniform.

IES-25. Match List-I (Device) with List-II (Component/Accessory) and select the correct answer using the codes given below the Lists: [IES-2003]

List-I (Device)	**List-II (Component/Accessory)**
A. Lifting machine	**1. Idler of Jockey pulley**
B. Fibre rope drive	**2. Sun wheel**
C. Differential gear	**3. Sheave**
D. Belt drive	**4. Power screw**

Codes:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	4	3	1	2	(b)	3	4	1	2
(c)	4	3	2	1	(d)	3	4	2	1

IES-25. Ans. (c)

IES-26. A pulley is connected to a power transmission shaft of diameter d by means of a rectangular sunk key of width wand length 'l'. The width of the key is taken as d/4. For full power transmission, the shearing strength of the key is equal to the torsional shearing strength of the shaft. The ratio of the length of the key to the diameter of the shaft (l/d) is [IES-2003]

(a) $\frac{\pi}{4}$ (b) $\frac{\pi}{\sqrt{2}}$ (c) $\frac{\pi}{2}$ (d) π

IES-26. Ans. (c)

$$\text{Shearing strength of key: } F = \tau.\left(\frac{d}{4}.l\right)$$

$$\text{Torque(T)} = F.\frac{d}{2} = \tau.\left(\frac{d}{4}.l\right).\frac{d}{2}$$

$$\text{Torsional shearing, } \frac{T}{\frac{\pi d^4}{32}} = \frac{\tau}{\frac{d}{2}}$$

$$\text{or } T = \pi d^3 \times \frac{\tau}{16}$$

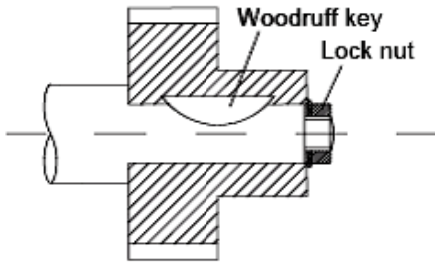
For same strength

$$\tau.\left(\frac{d}{4}.l\right).\frac{d}{2} = \pi d^3 \times \frac{\tau}{16}$$

$$\text{or } \frac{l}{d} = \frac{\pi}{2}$$

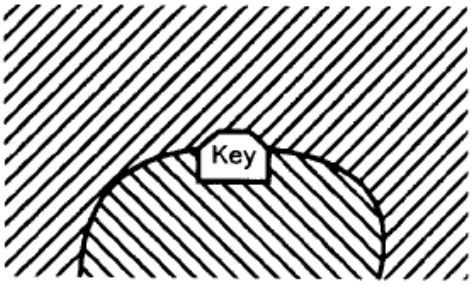
IES-27. **Assertion (A):** A Woodruff key is an easily adjustable key.
Reason (R): The Woodruff key accommodates itself to any taper in the hub or boss of the mating piece. **[IES-2003]**
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-27. Ans. (b)



The main advantages of a woodruff key are as follows:
1. It accommodates itself to any taper in the hub or boss of the mating piece.
2. It is useful on tapering shaft ends. Its extra depth in the shaft prevents any tendency to turn over in its keyway.
The main dis-advantages of a woodruff key are as follows:
1. The depth of the keyway weakens the shaft.
2. It can not be used as a feather.

IES-28. **The key shown in the above figure is a**



(a) Barth key

(b) Kennedy key

(c) Lewis key

(d) Woodruff key

[IES-2000]

IES-28. Ans. (a)

IES-29. **Match List I (Keys) with List II (Characteristics) and select the correct answer using the codes given below the Lists:** **[IES-2000]**

List I	**List II**
A. Saddle key	**1. Strong in shear and crushing**
B. Woodruff key	**2. Withstands tension in one direction**
C. Tangent key	**3. Transmission of power through frictional resistance**
D. Kennedy key	**4. Semicircular in shape**

Code:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	3	4	1	2	(b)	4	3	2	1
(c)	4	3	1	2	(d)	3	4	2	1

IES-29. Ans. (d)

IES-30. **Match List-I with List-II and select the correct answer using the code given below the Lists: [IES-2009]**

List-I ***(Description)***	***List-II (shape)***
A. Spline	**1. Involute**
B. Roll pin	**2. Semicircular**
C. Gib-headed key	**3. Tapered on on side**
D. Woodruff key	**4. Circular**

Code:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	1	3	4	2	(b)	2	3	4	1
(c)	1	4	3	2	(d)	2	4	3	1

IES-30. Ans. (c)

IES-31. **The shearing area of a key of length 'L', breadth 'b' and depth 'h' is equal to**
(a) b x h (b) Lx h (c) Lx b (d) Lx (h/2) **[IES-1998]**

IES-31. Ans. (c)

Splines

IES-32. **Consider the following statements:** **[IES-1998]**
A splined shaft is used for
1. Transmitting power
2. Holding a flywheel rigidly in position
3. Moving axially the gear wheels mounted on it
4. Mounting V-belt pulleys on it.
Of these statements
(a) 2 and 3 are correct (b) 1 and 4 are correct
(c) 2 and 4 are correct (d) 1 and 3 are correct

IES-32. Ans. (d)

Welded joints

IES-33. In a fillet welded joint, the weakest area of the weld is **[IES-2002]**

(a) Toe (b) root (c) throat (d) face

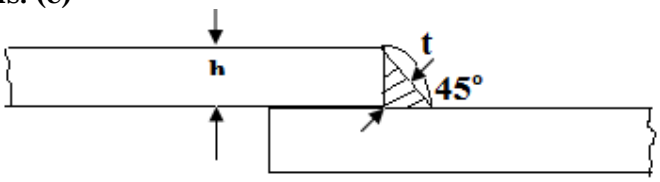
IES-33. Ans. (c)

IES-34. A single parallel fillet weld of total length L and weld size h subjected to a tensile load P, will have what design stress? **[IES 2007]**

(a) Tensile and equal to $\frac{P}{0.707Lh}$ (b) Tensile and equal to $\frac{P}{Lh}$

(c) Shear and equal to $\frac{P}{0.707Lh}$ (d) Shear and equal to $\frac{P}{Lh}$

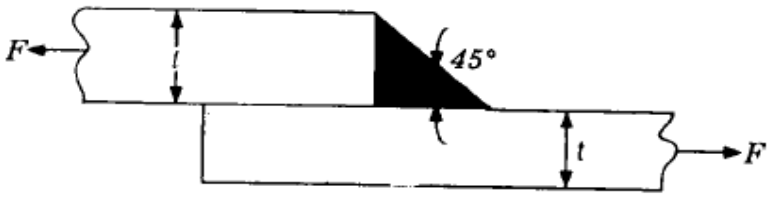
IES-34. Ans. (c)



Throat, $t = h\cos 45^0 = \frac{1}{v_2}h = 0.707h$

$$T = \frac{P}{Lt} = \frac{P}{0.707Lh}$$

IES-35. Two metal plates of thickness 't' and width 'w' are joined by a fillet weld of 45° as shown in given figure.



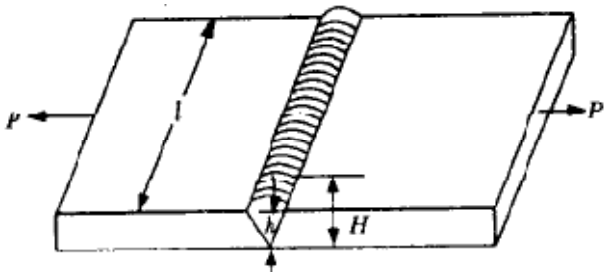
[IES-1998]

When subjected to a pulling force 'F', the stress induced in the weld will be

(a) $\frac{F}{wt\sin 45^o}$ (b) $\frac{F}{wt}$ (c) $\frac{F\sin 45^o}{wt}$ (d) $\frac{2F}{wt}$

IES-35. Ans. (a)

IES-36. A butt welded joint, subjected to tensile force P is shown in the given figure, l = length of the weld (in mm) h = throat of the butt weld (in mm) and H is the total height of weld including reinforcement. The average tensile stress σ_t, in the weld is given by

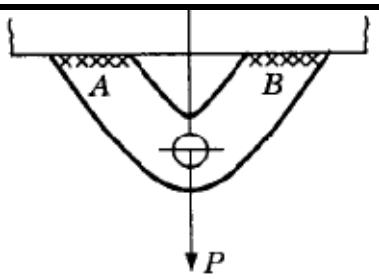


[IES-1997]

(a) $\sigma_t = \frac{P}{Hl}$ (b) $\sigma_t = \frac{P}{hl}$ (c) $\sigma_t = \frac{P}{2hl}$ (d) $\sigma_t = \frac{2P}{Hl}$

IES-36. Ans. (b)

IES-37. **In the welded joint shown in the given figure, if the weld at B has thicker fillets than that at A, then the load carrying capacity P, of the joint will**



(a) increase
(b) decrease
(c) remain unaffected
(d) exactly get doubled

[IES-1997]

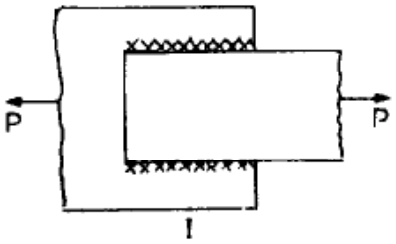
IES-37. Ans. (c)

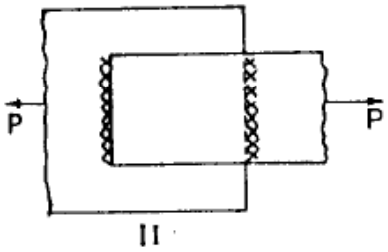
IES-38. **A double fillet welded joint with parallel fillet weld of length L and leg B is subjected to a tensile force P. Assuming uniform stress distribution, the shear stress in the weld is given by** **[IES-1996]**

(a) $\frac{\sqrt{2}P}{B.L}$ (b) $\frac{P}{2.B.L}$ (c) $\frac{P}{\sqrt{2}.B.L}$ (d) $\frac{2P}{B.L}$

IES-38. Ans. (c)

IES-39. **The following two figures show welded joints (x x x x x indicates welds), for the same load and same dimensions of plate and weld.** **[IES-1994]**





The joint shown in

(a) fig. I is better because the weld is in shear and the principal stress in the weld is not in line with P
(b) fig. I is better because the load transfer from the tie bar to the plate is not direct
(c) fig. II is better because the weld is in tension and safe stress of weld in tension is greater than that in shear
(d) fig. II is better because it has less stress concentration.

IES-39. Ans. (c) Figure II is better because the weld is in tension and safe stress of weld in tension is greater than shear.

IES-40. **Assertion (A):** In design of double fillet welding of unsymmetrical sections with plates subjected to axial loads lengths of parallel welds are made unequal.
Reason (R): The lengths of parallel welds in fillet welding of an unsymmetrical section with a plate are so proportioned that the sum of the resisting moments of welds about the centre of gravity axis is zero. **[IES-2008]**

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-40. Ans. (a) Axially loaded unsymmetrical welded joints

$$\tau = \frac{P_1}{A_1}$$

$$P_1 = \tau A_1$$

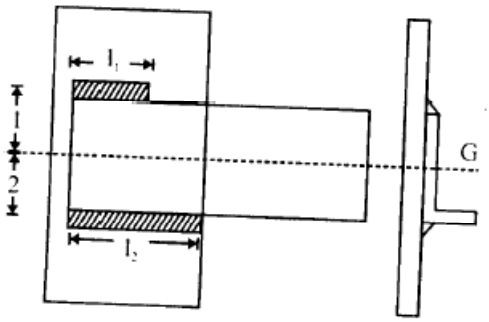
$$P_1 = \tau \times t \times l_1$$

$$P_2 = \tau \times t \times l_2$$

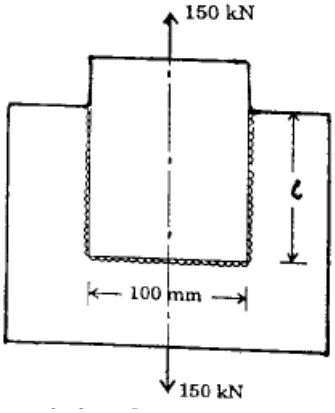
$$P_1 y_1 = P_2 y_2$$

$$\tau t l_1 y_1 = \tau t l_2 y_2$$

$$l_1 y_1 = l_2 y_2$$



IES-41. Two plates are joined together by means of single transverse and double parallel fillet welds as shown in figure given above. If the size of fillet is 5 mm and allowable shear load per mm is 300 N, what is the approximate length of each parallel fillet?



(a) 150 mm

(b) 200 mm

(c) 250 mm

(d) 300 mm

[IES-2005]

IES-41. Ans. (b) $300 \times (100 + 2l) = 15000 \quad \text{or} \quad l = 200$

IES-42. A circular rod of diameter d is welded to a flat plate along its circumference by fillet weld of thickness t. Assuming τ_w as the allowable shear stress for the weld material, what is the value of the safe torque that can be transmitted? **[IES-2004]**

(a) $\pi d^2.t.\tau_w$ (b) $\frac{\pi d^2}{2}.t.\tau_w$ (c) $\frac{\pi d^2}{2\sqrt{2}}.t.\tau_w$ (d) $\frac{\pi d^2}{\sqrt{2}}.t.\tau_w$

IES-42. Ans. (b)

$$\text{Shear stress} = \tau_W$$

$$\text{Shear fore} = \tau_W \times \pi dt$$

$$\text{Torque}(T) = \tau_W \times \pi dt \times \frac{d}{2} = \frac{\pi d^2}{2}.t\tau_W$$

IES-43. A circular solid rod of diameter d welded to a rigid flat plate by a circular fillet weld of throat thickness t is subjected to a twisting moment T. The maximum shear stress induced in the weld is **[IES-2003]**

(a) $\frac{T}{\pi td^2}$ (b) $\frac{2T}{\pi td^2}$ (c) $\frac{4T}{\pi td^2}$ (d) $\frac{2T}{\pi td^3}$

IES-43. Ans. (b) $\tau = \frac{T.r}{J} = \frac{T.\left(\frac{d}{2}\right)}{\frac{\pi td^3}{4}} = \frac{2T}{\pi td^2}$

IES-44. The permissible stress in a filled weld is 100 N/mm². The fillet weld has equal leg lengths of 15 mm each. The allowable shearing load on weldment per cm length of the weld is **[IES-1995]**

(a) 22.5 kN (b) 15.0 kN (c) 10.6 kN (d) 7.5 kN.

IES-44. Ans. (c) Load allowed = 100 x 0.707 x 10 x15 = 10.6 kN

Threaded fasteners

IES-45. **A force 'F' is to be transmitted through a square-threaded power screw into a nut. If 't' is the height of the nut and 'd' is the minor diameter, then which one of the following is the average shear stress over the screw thread?** **[IES 2007]**

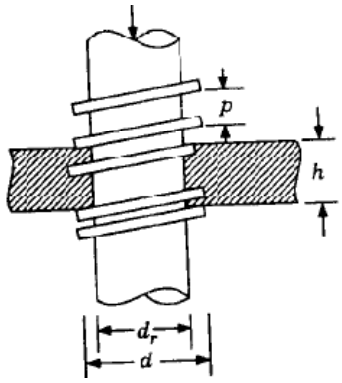
(a) $\frac{2f}{\pi dt}$ (b) $\frac{F}{\pi dt}$ (c) $\frac{F}{2\pi dt}$ (d) $\frac{4F}{\pi dt}$

IES-45. Ans. (b)

IES-46. **Consider the case of a square-threaded screw loaded by a nut as shown in the given figure. The value of the average shearing stress of the screw is given by (symbols have the usual meaning)**

(a) $\frac{2F}{\pi d_r h}$ (b) $\frac{F}{\pi d_r h}$

(c) $\frac{2F}{\pi dh}$ (d) $\frac{F}{\pi dh}$



[IES-1997]

IES-46. Ans. (b)

IES-47. **Assertion (A):** Uniform-strength bolts are used for resisting impact loads.
Reason (R): The area of cross-section of the threaded and unthreaded parts is made equal. **[IES-1994]**

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-47. Ans. (c) A is true and R is false.

IES-48. **How can shock absorbing capacity of a bolt be increased?** **[IES 2007]**

(a) By tightening it property
(b) By increasing the shank diameter
(c) By grinding the shank
(d) By making the shank diameter equal to the core diameter of thread

IES-48. Ans. (d)

IES-49. **The number of slots is a 25 mm castle nut is** **[IES-1992]**

(a) 2 (b) 4 (c) 6 (d) 8

IES-49. Ans. (c)

2. Design of Friction Drives

Objective Questions (GATE, IES & IAS)

Previous 20-Years GATE Questions

Couplings

GATE-1. **The bolts in a rigid flanged coupling connecting two shafts transmitting power are subjected to** **[GATE-1996]**
(a) Shear force and bending moment (b) axial force.
(c) Torsion and bending moment (d) torsion

GATE-1. **Ans. (a)** The bolts are subjected to shear and bearing stresses while transmitting torque.

Uniform pressure theory

GATE-2. **A clutch has outer and inner diameters 100 mm and 40 mm respectively. Assuming a uniform pressure of 2 MPa and coefficient of friction of liner material 0.4, the torque carrying capacity of the clutch is** **[GATE-2008]**
(a) 148 Nm (b) 196 Nm (c) 372 Nm (d) 490 Nm

GATE-2. Ans. (b) $\text{Force(P)} = \frac{\pi p}{4}\left(D^2 - d^2\right)$

$$T = \frac{\mu P}{3}\cdot\frac{\left(D^3 - d^3\right)}{\left(D^2 - d^2\right)}$$

$$= \frac{\mu\pi}{12}.p.\left(D^3 - d^3\right) = \frac{0.4\times\pi\times 2\times 10^6}{12}\left(0.1^3 - 0.04^3\right) = 196\text{Nm}$$

GATE-3. **A disk clutch is required to transmit 5 kW at 2000 rpm. The disk has a friction lining with coefficient of friction equal to 0.25. Bore radius of friction lining is equal to 25 mm. Assume uniform contact pressure of 1 MPa. The value of outside radius of the friction lining is** **[GATE-2006]**
(a) 39.4 mm (b) 49.5 mm (c) 97.9 mm (d) 142.9 mm

GATE-3. Ans.(a)

$$\text{Torque}, T = \frac{P\times 60}{2\pi\times N} = 23.87\,\text{N m}$$

$$= \text{Axial thrust}, W = P\times\pi(r_1^{\,2} - r_2^{\,2})$$

$$\text{But} \qquad T = \frac{2}{3}\mu\times P\times\pi(r_1^{\,2} - r_2^{\,2})\frac{(r_1^{\,3} - r_2^{\,3})}{(r_1^{\,2} - r_2^{\,2})} = \mu wr$$

$$\therefore \qquad r_2 = 39.4\,\text{mm}$$

Design of Friction Drives

S K Mondal's Chapter 2

Belt and Chain drives

GATE-4. Total slip will Occur in a belt drive when [GATE-1997]

(a) Angle of rest is zero
(b) Angle of creep is zero
(c) Angle of rest is greater than angle of creep
(d) Angle of creep is greater than angle of rest

GATE-4. Ans. (a)

Belt tension

GATE-5. The ratio of tension on the tight side to that on the slack side in a flat belt drive is [GATE-2000]

(a) Proportional to the product of coefficient of friction and lap angle
(b) An exponential function of the product of coefficient of friction and lap angle.
(c) Proportional to the lap angle
(d) Proportional to the coefficient of friction

GATE-5. Ans. (b)

$$\frac{T_1}{T_2} = \ell^{\mu 0}$$

GATE-6. The difference between tensions on the tight and slack sides of a belt drive is 3000 N. If the belt speed is 15 m/s, the transmitted power in k W is

(a) 45 (b) 22.5 (c) 90 (d) 100 **[GATE-1998]**

GATE-6. Ans. (a)

Given, $T_1 - T_2 = 3000\text{N}$

where $T_1 T_2 = \text{tensions on tight an d slack side respectively}$

$v = \text{belt speed} = 15\,\text{m/sec}$

$\text{Power} = (T_1 - T_2)v$

$= 3000 \times 45000\,\text{watt} = 45\,\text{kW}$

GATE-7. The percentage improvement in power capacity of a flat belt drive, when the wrap angle at the driving pulley is increased from 150° to 210° by an idler arrangement for a friction coefficient of 0.3, is [GATE-1997]

(a) 25.21 (b) 33.92 (c) 40.17 (d) 67.85

GATE-7. Ans. (d) We know that Power transmitted (P) = $(T_1 - T_2).v$ W

Case-I: $\frac{T_1}{T_2} = e^{\mu\theta}$ or $\frac{T_1}{T_2} = e^{0.3\times\left(\frac{5\pi}{6}\right)}$ or $T_1 = 2.193\,T_2 \Rightarrow P_1 = 1.193 T_2 V$ W

Case-II: $\frac{T_1}{T_2} = e^{\mu\theta}$ or $\frac{T_1}{T_2} = e^{0.3\times\left(\frac{7\pi}{6}\right)}$ or $T_1 = 3.003\,T_2 \Rightarrow P_1 = 2.003 T_2 V$ W

Therefore improvement in power capacity $= \frac{P_2 - P_1}{P_1} \times 100\% = 67.88\%$

Centrifugal tension

GATE-8. With regard to belt drives with given pulley diameters, centre distance and coefficient of friction between the pulley and the belt materials, which of the statement below are FALSE? [GATE-1999]

(a) A crossed flat belt configuration can transmit more power than an open flat belt configuration

(b) A "V" belt has greater power transmission capacity than an open flat belt
(c) Power transmission is greater when belt tension is higher due to centrifugal effects than the same belt drive when centrifugal effects are absent.
(d) Power transmission is the greatest just before the point of slipping is reached

GATE-8. Ans. (c)

Rope drive

GATE-9. In a 6×20 wire rope, No.6 indicates the [GATE-2003]
(a) diameter of the wire rope in mm
(b) Number of strands in the wire rope
(c) Number of wires
(d) Gauge number of the wire

GATE-9. Ans. (b) 6×20 wire rope: 6 indicates number of strands in the wire rope and 20 indicates no of wire in a strand.

Self locking screw

GATE-10. What is the efficiency of a self-locking power screw? [GATE-1994]
(a) 70% (b) 60% (c) 55% (d) < 50 %

GATE-10. Ans. (d) We know that the frictional torque for square thread at mean radius while raising load is given by $WR_o \tan(\phi - \alpha)$

Where: (W = load; R_o = Mean Radius; φ = Angle of friction; α = Helix angle)
For self locking, angle of friction should be greater than helix angle of screw So that $WR_o \tan(\phi - \alpha)$ will become positive. i.e. we have to give torque to lowering the load.

GATE-11. Self locking in power screw is better achieved by decreasing the helix angle and increasing the coefficient of friction. [GATE-1995]
(a) True (b) False (c) insufficient logic (d) none of the above

GATE-11. Ans. (a)

Efficiency of screw

GATE-12. Which one of the following is the value of helix angle for maximum efficiency of a square threaded screw? [$\phi = \tan^{-1}\mu$] [GATE-1997]
(a) $45^o + \phi$ (b) $45^o - \phi$ (c) $45^o - \phi/2$ (d) $45^o + \phi/2$

GATE-12. Ans. (c)

Previous 20-Years IES Questions

Couplings

IES-1. Consider the following statements in respect of flexible couplings:
1. The flanges of flexible coupling are usually made of grey cast iron FG200. [IES-2006]
2. In the analysis of flexible coupling, it is assumed that the power is transmitted by the shear resistance of the pins.
3. Rubber bushes with brass lining are provided to absorb misalignment between the two shafts.
Which of the statements given above are correct?
(a) 1, 2 and 3 (b) Only 1 and 2 (c) Only 2 and 3 (d) Only 1 and 3

IES-1. Ans. (d) Since the pin is subjected to bending and shear stresses, therefore the design must be checked either for the maximum principal stress or maximum shear stress theory.

IES-2. Which of the following stresses are associated with the design of pins in bushed pin-type flexible coupling? [IES-1998]
1. Bearing stress 2. Bending stress
3. Axial tensile stress 4. Transverse shear stress
Select the correct answer using the codes given below
(a) 1, 3 and 4 (b) 2, 3 and 4 (c) 1, 2 and 3 (d) 1, 2 and 4

IES-2. Ans. (d)

IES-3. Match List I with List II and select the correct answer using the codes given below the lists: [IES-1995]

List I	List II
A. Crank shaft	1. Supports the revolving parts and transmits torque.
B. Wire shaft	2. Transmits motion between shafts where it is not possible to effect a rigid coupling between them
C. Axle	3. Converts linear motion into rotary motion
D. Plain shaft	4. Supports only the revolving parts.

Codes:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	3	2	1	4	(b)	4	2	3	1
(c)	3	2	4	1	(d)	1	4	2	3

IES-3. Ans. (c)

IES-4. The bolts in a rigid flanged coupling connecting two shafts transmitting power are subjected to [IES-2002]
(a) Shear force and bending moment (b) axial force.
(c) Torsion and bending moment (d) torsion

IES-4. Ans. (a) The bolts are subjected to shear and bearing stresses while transmitting torque.

Introduction Friction clutches

IES-5. Which one of the following is not a friction clutch? [IES-2003]
(a) Disc or plate clutch (b) Cone clutch
(c) Centrifugal clutch (d) Jaw clutch

IES-5. Ans. (d)

IES-6. Which one of the following pairs of parameters and effects is not correctly matched? [IES-1998]
(a) Large wheel diameter .....Reduced wheel wear
(b) Large depth of cut .....Increased wheel wear
(c) Large work diameter .....Increased wheel wear
(d) Large wheel speed .....Reduced wheel wear

IES-6. Ans. (d)

IES-7. Two co-axial rotors having moments of inertia I_1, I_2 and angular speeds ω_1 and ω_2 respectively are engaged together. The loss of energy during engagement is equal to [IES-1994]
(a) $\frac{I_1 I_2 (\omega_1 - \omega_2)^2}{2(I_1 + I_2)}$ (b) $\frac{I_1 I_2 (\omega_1 - \omega_2)^2}{2(I_1 - I_2)}$ (c) $\frac{2 I_1 I_2 (\omega_1 - \omega_2)^2}{(I_1 + I_2)}$ (d) $\frac{I_1 \omega_1^2 - I_2 \omega_2^2}{(I_1 + I_2)}$

IES-7. Ans. (c)

IES-8. Which of the following statements hold good for a multi-collar thrust bearing carrying an axial thrust of W units? [IES-1996]
1. Friction moment is independent of the number of collars.
2. The intensity of pressure is affected by the number of collars.
3. Co-efficient of friction of the bearing surface is affected by the number of collars.
(a) 1 and 2 (b) 1 and 3 (c) 2 and 3 (d) 1, 2 and 3

IES-8. Ans. (a)

IES-9. Which of the following statements regarding laws governing the friction between dry surfaces are correct? [IES-1996]
1. The friction force is dependent on the velocity of sliding.
2. The friction force is directly proportional to the normal force.
3. The friction force is dependent on the materials of the contact surfaces.
4. The frictional force is independent of the area of contact
(a) 2, 3 and 4 (b) 1 and 3 (c) 2 and 4 (d) 1, 2, 3 and 4

IES-9. Ans. (a)

Uniform pressure theory

IES-10. Assertion (A): In case of friction clutches, uniform wear theory should be considered for power transmission calculation rather than the uniform pressure theory.
Reason (R): The uniform pressure theory gives a higher friction torque than the uniform wear theory. **[IES-2003]**
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-10. Ans. (b) Uniform pressure theory is applicable only when the clutches are new i.e., the assumption involved is that axial force W is uniformly distributed.
Moreover torque transmitted in uniform pressure is more hence for safety in design uniform wear theory is used.

IES-11. When the intensity of pressure is uniform in a flat pivot bearing of radius r, the friction force is assumed to act at [IES-2001]
(a) r (b) r/2 (c) 2r/3 (d) r/3

IES-11. Ans. (c)

IES-12. In a flat collar pivot bearing, the moment due to friction is proportional to (r_1 and r_2 are the outer and inner radii respectively) [IES-1993]
(a) $\frac{r_1^2 - r_2^2}{r_1 - r_2}$ (b) $\frac{r_1^2 - r_2^2}{r_1 + r_2}$ (c) $\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}$ (d) $\frac{r_1^3 - r_2^3}{r_1 - r_2}$

IES-12. Ans. (c)

Uniform wear theory

IES-13. In designing a plate clutch, assumption of uniform wear conditions is made because [IES-1996]
(a) It is closer to real life situation (b) it leads to a safer design.
(c) It leads to cost effective design (d) no other assumption is possible.

IES-13. Ans. (a)

Multi-disk clutches

IES-14. In case of a multiple disc clutch, if n_1 is the number of discs on the driving shaft and n_2 is the number of discs on the driven shaft, then what is the number of pairs of contact surfaces? [IES-2008]

(a) $n_1 + n_2$ (b) $n_1 + n_2 - 1$ (c) $n_1 + n_2 + 1$ (d) $n_1 + 2n_2$

IES-14. Ans. (b)

IES-15. In a multiple disc clutch if n_1 and n_2 are the number of discs on the driving and driven shafts, respectively, the number of pairs of contact surfaces will be [IES-2001; 2003]

(a) $n_1 + n_2$ (b) $n_1 + n_2 - 1$ (c) $n_1 + n_2 + 1$ (d) $\frac{n_1 + n_2}{2}$

IES-15. Ans. (b)

IES-16. In the multiple disc clutch, If there are 6 discs on the driving shaft and 5 discs on the driven shaft, then the number of pairs of contact surfaces will be equal to [IES-1997]

(a) 11 (b) 12 (c) 10 (d) 22

IES-16. Ans. (c) No. of active plates = 6 + 5 - 1 = 10

Cone clutches

IES-17. Which one of the following is the correct expression for the torque transmitted by a conical clutch of outer radius R, Inner radius r and semi-cone angle α assuming uniform pressure? (Where W = total axial load and μ = coefficient of friction) [IES-2004]

(a) $\frac{\mu W(R + r)}{2\sin\alpha}$ (b) $\frac{\mu W(R + r)}{3\sin\alpha}$

(c) $\frac{2\mu W(R^3 - r^3)}{3\sin\alpha(R^2 - r^2)}$ (d) $\frac{3\mu W(R^3 - r^3)}{4\sin\alpha(R^2 - r^2)}$

IES-17. Ans. (c)

Centrifugal clutches

IES-18. On the motors with low starting torque, the type of the clutch to be used is [IES-2003]

(a) Multiple-plate clutch (b) Cone clutch
(c) Centrifugal clutch (d) Single-plate clutch with both sides effective

IES-18. Ans. (c)

IES-19. Consider the following statements regarding a centrifugal clutch: [IES-2000]
It need not be unloaded before engagement.
1. It enables the prime mover to start up under no-load conditions.
2. It picks up the load gradually with the increase in speed
3. It will not slip to the point of destruction
4. It is very useful when the power unit has a low starting torque
Which of these are the advantages of centrifugal clutch?

(a) 1, 2 and 4 (b) 1, 3 and 5 (c) 2, 3 and 5 (d) 1, 3, 4 and 5

IES-19. Ans. (c)

IES-20. Match List-I with List-II and select the correct answer using the codes given below the lists: [IES-1998]

List-I **List-II**

A. Single-plate friction clutch					**1. Scooters**				
B. Multi-plate friction clutch					**2. Rolling mills**				
C. Centrifugal clutch					**3. Trucks**				
D. Jaw clutch					**4. Mopeds**				
Code:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	1	3	4	2	(b)	1	3	2	4
(c)	3	1	2	4	(d)	3	1	4	2

IES-20. Ans. (d)

Belt and Chain drives

IES-21. **The creep in a belt drive is due to the** **[IES-2001]**

(a) Material of the pulleys
(b) Material of the belt
(c) Unequal size of the pulleys
(d) Unequal tension on tight and slack sides of the belt

IES-21. Ans. (d)

- When the belt passes from the slack side to the tight side, a certain portion of the belt extends and it contracts again when the belt passes from the tight side to the slack side. Due to these changes of length, there is a relative motion between the belt and the pulley surfaces. This relative motion is termed as creep. The total effect of creep is to reduce slightly the speed of the driven pulley or follower.
- Here english meaning of 'creep' is 'very slow motion' and not 'When a part is subjected to a constant stress at high temperature for a long period of time, it will undergo a slow and permanent deformation called creep.'
- Therefore the belt creep is very slow motion between the belt and the pulley surfaces due to unequal tension on tight and slack sides of the belt.
- Don't confuse with material of the belt because the belt creep depends on both the materials of the pulley and the materials of the belt.

IES-22. **Assertion (A):** In design of arms of a pulley, in belt drive, the cross-section of the arm is, elliptical with minor axis placed along the plane of rotation. **[IES-2001]**
Reason (R): Arms of a pulley in belt drive are subjected to complete reversal of stresses and is designed for bending in the plane of rotation.

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-22. Ans. (a)

IES-23. **Assertion (A):** In pulley design of flat belt drive, the cross-sections of arms are made elliptical with major axis lying in the plane of rotation. **[IES-1999]**
Reason (R): Arms of a pulley in belt drive are subjected to torsional shear stresses and are designed for torsion.

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-23. Ans. (c)

IES-24. **Which one of the following belts should not be used above 40°C?** **[IES-1999]**

(a) Balata belt (b) Rubber belt (c) Fabric belt (d) Synthetic belt

IES-24. Ans. (b)

IES-25. **In μ is the actual coefficient of friction in a belt moving in grooved pulley, the groove angle being 2α, the virtual coefficient of friction will be**

(a) $\mu / \sin\alpha$ (b) $\mu / \cos\alpha$ (c) $\mu \sin\alpha$ (d) $\mu \cos\alpha$ **[IES-1997]**

IES-25. Ans. (a)

IES-26. In flat belt drive, if the slip between the driver and the belt is 1%, that between belt and follower is 3% and driver and follower pulley diameters are equal, then the velocity ratio of the drive will be **[IES-1996]**

(a) 0.99 (b) 0.98 (c) 0.97 (d) 0.96.

IES-26. Ans. (d)

IES-27. Assertion (A): Crowning is provided on the surface of a flat pulley to prevent slipping of the belt sideways. **[IES-2006]**

Reason (R): Bell creep, which is the reason for slip of the belt sideways, is fully compensated by providing crowning on the pulley.

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-27. Ans. (c) Belt creep has no effect on sideways.

Length of the belt

IES-28. The length of the belt in the case of a cross-belt drive is given in terms of centre distance between pulleys (C), diameters of the pulleys D and d as

(a) $2C + \frac{\pi}{2}(D + d) + \frac{(D + d)^2}{4C}$ (b) $2C + \frac{\pi}{2}(D - d) + \frac{(D + d)^2}{4C}$ **[IES-2002]**

(c) $2C + \frac{\pi}{2}(D + d) + \frac{(D - d)^2}{4C}$ (d) $2C + \frac{\pi}{2}(D - d) + \frac{(D - d)^2}{4C}$

IES-28. Ans. (a)

IES-29. Assertion (A): Two pulleys connected by a crossed belt rotate in opposite directions.

Reason (R): The length of the crossed belt remains constant. **[IES-2008]**

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-29. Ans. (b) Two pulleys connected by open belt rotate in same direction whereas two pulleys connected by crossed belt rotate in opposite direction.

The length of crossed belt is given by

$$L_c = \pi(r_1 + r_2) + 2C + \left(\frac{r_1 + r_2}{C}\right)^2$$

So length of crossed belt in constant. Both the statements are correct but Reason is not the correct explanation of Assertion.

IES-30. Which one of the following statements relating to belt drives is correct?

(a) The rotational speeds of the pulleys are directly proportional to their diameters
(b) The length of the crossed belt increases as the sum of the diameters of the pulleys increases
(c) The crowning of the pulleys is done to make the drive sturdy
(d) The slip increases the velocity ratio **[IES 2007]**

IES-30 Ans.(b) $L = \pi(r_1 + r_2) + 2C + \frac{(r_1 + r_2)^2}{C}$ where C = centre distance of shafts.

Belt tension

IES-31. **Assertion (A):** In a short centre open-belt drive, an idler pulley is used to maintain the belt tension and to increase the angle of contact on the smaller pulley.
Reason (R): An idler pulley is free to rotate on its axis and is put on the slack side of the belt. **[IES-1994]**
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-31Ans. (a) Both A and R are true, and R provides correct explanation for A.

IES-32. **In a Belt drive, if the pulley diameter is doubled keeping the tension and belt width constant, then it will be necessary to [IES-1993]**
(a) Increase the key length (b) increase the key depth
(c) Increase the key width (d) decrease the key length

IES-32Ans. (c) Due to twice increase in diameter of pulley, torque on key is double and has to be resisted by key width. Length can't be increased as belt width is same.

IES-33. **The following data refers to an open belt drive: [IES-1993]**

	Pulley A	Pulley B
Purpose	**Driving**	**Driven**
Diameter.....	**450 mm**	**750 mm**
Angle of contact.....	**$\theta_A = 150^o$**	**$\theta_A = 210^o$**
Coefficient of friction between belt and pulley	$f_A = 0.36$	$f_A = 0.22$

The ratio of tensions may be calculated using the relation (T_1/T_2) = exp (z) where z is
$(a)\ f_A\theta_A \quad (b)\ f_B\theta_B \quad (c)(f_A + f_B)(\theta_A + \theta_B)/4 \quad (d)(f_A\theta_A + f_B\theta_B)/2$

IES-33Ans. (a) $\frac{T_1}{T_2} = e^{f_A\theta_A}$ where f and θ are taken for smaller pulley.

Centrifugal tension

IES-34. **Centrifugal tension in belts is [IES-1999]**
(a) Useful because it maintains some tension even when no power is transmitted
(b) Not harmful because it does not take part in power transmission
(c) Harmful because it increases belt tension and rfeduces the power transmitted
(d) A hypothetical phenomenon and does not actually exist in belts

IES-34.Ans. (c)

IES-35. **In the case of a vertical belt pulley drive with T_c as centrifugal tension and T_o as the initial tension, the belt would tend to hang clear of the tower pulley when [IES-1997]**

$(a) T_c < T_o \quad (b)\ T_c < T_o/3 \quad (c)\ T_c > T_o \quad (d) T_c < T_o/2$

IES-35Ans. (c)

IES-36. **Consider the following statements in case of belt drives: [IES 2007]**
1. Centrifugal tension in the belt increases the transmitted power.
2. Centrifugal tension does not affect the driving tension
3. Maximum tension in the belt is always three times the centrifugal tension.
Which of the statements given above is/are correct?

(a) 1, 2 and 3 (b) 2 and 3 only
(c) 1 and 3 only (d) 1 only

IES-36Ans. (b)

IES-37. In case of belt drives, the effect of the centrifugal tension is to: [IES-2006]
(a) Cause the belt to leave the pulley and increase the power to be transmitted
(b) Cause the belts to stay on the pulley and increase the power to be transmitted
(c) Reduce the driving power of the belt
(d) Stretch the belt in longitudinal direction

IES-37Ans. (d) Centrifugal tension has no effect on the power to be transmitted.

$$T_C = m.v^2$$

When centrifugal tension is taken into account, then total tension in the tight side,

$$T_{t1} = T_1 + T_C$$

and total tension in the slack side,

$$T_{t2} = T_2 + T_C$$

Power transmitted,

$$P = (T_{t1} - T_{t2})\, v$$
$$= [(T_1 + T_C) - (T_2 + T_C)]v = (T_1 - T_2)\, v \quad \text{... (same as before)}$$

Condition for maximum power

IES-38. In a flat belt drive the belt can be subjected to a maximum tension T and centrifugal tension T_c . What is the condition for transmission of maximum power? [IES-2008]
(a) $T=T_c$ (b) $T=\sqrt{3}\,T_c$ (c) $T=2T_c$ (d) $T=3T_c$

IES-38Ans. (d)

Condition for maximum power transmission:-

$$P = (T_1 - T_2)v$$

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$$\Rightarrow \quad P = (T_{max} - T_c)\left(1 - \frac{1}{e^{\mu\theta}}\right)v$$

$$\Rightarrow \quad P = \left(T_{max}v - mv^3\right)1 - \frac{1}{e^{\mu\theta}}$$

$$\Rightarrow \quad \frac{dP}{dv} = \left(T_{max} - 3mv^2\right) = 0$$

$$\Rightarrow \quad mv^2 = \frac{T_{max}}{3}$$

$$\Rightarrow \quad T_c = \frac{T_{max}}{3}$$

$$\therefore \quad T_{max} = 3T_c$$

IES-39. Which one of the following statements with regard to belt drives is NOT correct? [IES-2000]
(a) Increase in the angle of wrap of the belt enables more power transmission
(b) Maximum power is transmitted when the centrifugal tension is three times the tight side tension
(c) Wide and thin belt is preferable for better life than a thick and narrow one
(d) Crown is provided on the pulley to make the belt run centrally on the pulley

IES-39.Ans. (b)

IES-40. When a belt drive is transmitting maximum power [IES-1996]
(a) Effective tension is equal to centrifugal tension.
(b) Effective tension is half of centrifugal tension.
(c) Driving tension on slack side is equal to the centrifugal tension.
(d) Driving tension on tight side is twice the centrifugal tension.

IES-40Ans. (d)

IES-41. The power transmitted by a belt is dependent on the centrifugal effect in the belt. The maximum power can be transmitted when the centrifugal tension is [IES-2002]
(a) 1/3 of tension (T_1) on the tight side
(b) 1/3 of total tension (T_t) on the tight side
(c) 1/3 of tension (T_2) on the slack side
(d) 1/3 of sum of tensions T_1 and T_2 i.e. 1/3 ($T_1 + T_2$)

IES-41Ans. (b)

Selection of V-belt drive

IES-42. Assertion (A): For similar materials having the same maximum permissible tension V-belt transmits more power than flat belt with same velocity ratio and centre distance. **[IES-2001]**
Reason (R): As two sides of V-belt are in contact with side faces of pulley groove, larger contact area gives greater effective frictional force.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-42Ans. (a)

IES-43. In a multiple V belt drive, when a single belt is damaged, it is preferable to change the complete set to [IES-1993]
(a) Reduce vibration (b) reduce slip
(c) Ensure uniform loading (d) ensure proper alignment

IES-43Ans. (c) If a single belt breaks, all belts arc replaced to ensure uniform loading.

IES-44. Consider the following:
V-belts are specified by their [IES-2008]
1. Nominal inside length in mm
2. Nominal pitch length
3. Belt cross section symbol
4. weight/unit length of the belt
Which of the above are correct?
(a) 1, 2, 3 and 4 (b) 1 and 2 only
(c) 1 and 3 only (d) 3 and 4 only

IES-44Ans. (a)
V-belt designation
B – 2786 – Gr50 → standard size of belt
↓ ↓
Type nominal
of inside
v belt length

Initial tension in the belt

IES-45. Given that T_1 and T_2 are the tensions on the tight and slack sides of the belt respectively, the initial tension of the belt taking into account centrifugal tension T_c, is equal to [IES-1997]

(a) $\frac{T_1+T_2+T_c}{3}$ (b) $\frac{T_1+T_2+2T_c}{2}$ (c) $\frac{T_1+T_2+3T_c}{3}$ (d) $\frac{T_1-T_2+3T_c}{3}$

IES-45Ans. (b)

Chain drive

IES-46. Which one of the following drives is used for a constant velocity ratio, positive drive with large centre distance between the driver and driven shafts? IES-2004]

(a) Gear drive (b) Flat belt drive (c) Chain drive (d) V-belt drive

IES-46Ans. (c)

IES-47. Assertion (A): Slider-crank chain is an inversion of the four-bar mechanism.
Reason(R): Slider-crank chain often finds applications in most of the reciprocating machinery. **[IES-2003]**

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-47Ans. (b)

IES-48. Match List I (Applications) with List II (Drive element) and select the correct answer using the codes given below the Lists: [IES-2000]

List I	List II
A. Automobile differential	1. Flat belt
B. Bicycle	2. V-belt
C. Planning machine	3. Chain drive
D. Radiator fan of automobile	4. Gear drive

Code:	A	B	C	D		A	B	C	D
(a)	4	3	1	2	(b)	1	3	4	2
(c)	4	2	1	3	(d)	1	2	4	3

IES-48Ans. (a)

IES-49. Sources of power loss in a chain drive are given below: [IES-1995]
1. Friction between chain and sprocket teeth.
2. Overcoming the chain stiffness.
3. Overcoming the friction in shaft bearing.
4. Frictional resistance to the motion of the chain in air or lubricant.
The correct sequence of descending order of power loss due to these sources is

(a) 1,2,3,4 (b) 1,2,4,3 (c) 2,1,3,4 (d) 2,1,4,3

IES-49.Ans. (a) Power loss in descending order takes place as 1, 2 3 and 4.

IES-50. Given that P = chain pitch, c = centre distance, [IES-1994]
N, n = number of teeth on large and small sprocket respectively
the length of chain in terms of pitches can be approximated by

(a) $\frac{2c}{P}$ (b) $\frac{2c}{P}+N+n)/2$

(c) $\frac{2c}{P}+[(N-n)/2P]^2\frac{P}{c}$ (d) $\frac{2c}{P}+(N+n)/2P+[(N-n)/2P]^2\frac{P}{c}$

IES-50Ans. (d)

IES-51. For roller chain drive with sprocket having 10 teeth, the velocity of the driven shaft with respect to that of drive will be approximately [IES-2008]

(a) same
(b) 5% above
(c) 5% below
(d) 5% above to 5% below

IES-51Ans. (d)

$$(V_{max}-V_{min})\ \alpha\ \left[1-\cos\left(\frac{180}{z}\right)\right]$$

In order to reduce the variation in chain speed, the number of teeth on the sprocket should be increased. It has been observed that the speed variation is 4% for a sprocket with 11 teeth, 1.6% fro a sprocket with 24 teeth.

For smooth operation at moderate and high speeds, it is considered a good practice to use a driving sprocket with at least 17 teeth. For durability and noise considerations, the minimum number of teeth on the driving sprocket should be 19 or 21.

Rope drive

IES-52. In a 6×20 wire rope, No.6 indicates the [IES- 2001; 2003; 2007]

(a) diameter of the wire rope in mm
(b) Number of strands in the wire rope
(c) Number of wires
(d) Gauge number of the wire

IES-52Ans. (b) 6×20 wire rope: 6 indicates number of strands in the wire rope and 20 indicates no of wire in a strand.

IES-53. Consider the following types of stresses in respect of a hoisting rope during acceleration of load: [IES-2000]

1. Direct stress due to weight hoisted and weight of the rope
2. Bending stresses due to bending of rope over the sheave
3. Stresses due to initial tightening.
4. Acceleration stresses

Which of these are the correct types of stresses induced in a hoisting rope during acceleration of load?

(a)1, 2 and 3 (b) 2, 3 and 4 (c)1, 2 and 4 (d) 1, 3 and 4

IES-53Ans. (c)

IES-54. Assertion (A): In lifts, wire ropes are preferred over solid steel rods of same diameter.

Reason (R): Wire ropes are more flexible than steel rods and also provide plenty of time for remedial action before failure. **[IES-1999]**

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-54Ans. (a)

IES-55. Given that W = weight of load handled, W_r = weight of rope and f = acceleration, the additional load in ropes of a hoist during starting is given by [IES-1997]

$$(a)\ F_a = \left(\frac{W - W_r}{g}\right) f \qquad (b)\ F_a = \left(\frac{W + W_r}{g}\right) f \qquad (c)\ F_a = \frac{W}{g} f \qquad (d)\ F_a = \frac{W_r}{g} f$$

IES-55Ans. (b)

IES-56. Effective stress in wire ropes during normal working is equal to the stress due to [IES-1996]

(a) Axial load plus stress due to bending.
(b) Acceleration / retardation of masses plus stress due to bending.
(c) Axial load plus stress due to acceleration / retardation.
(d) bending plus stress due to acceleration/retardation.

IES-56Ans. (a)

IES-57. When compared to a rod of the same diameter and material, a wire rope

(a) Is less flexible **[IES-1994]**
(b) Has a much smaller load carrying capacity.
(c) Does not provide much warning before failure.
(d) Provides much greater time for remedial action before failure.

IES-57Ans. (d) A wire rope provides much greater time for remedial action before failure.

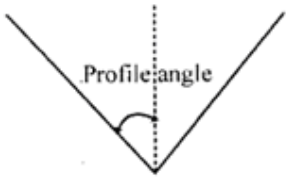
Types of power screw

IES-58. Power screws are used to produce uniform, slow and powerful motion such as required in presses, jacks and other machinery. 'V' threads are usually *not* used for this application due to low efficiency. This is because:

(a) Profile angle is zero (b) Profile angle is moderate **[IES-2005]**
(c) Profile angle is large (d) There is difficulty in manufacturing the profile

IES-58.Ans. (c)

Square thread most efficient. Profile angle is zero which causes excessive bursting force.



IES-59. Consider the following statements regarding power screws: [IES-1994]

1. The efficiency of a self-locking screw cannot be more than 50%.
2. If the friction angle is less than the helix angle of the screw, then the efficiency will be more than 50%.
3. The efficiency of ACME (trapezoidal thread) is less than that of a square thread.
Of these statements

(a) 1, 2 and 3 are correct (b) 2 and 3 are correct
(c) 1 and 3 are correct (d) 1 and 2 are correct

IES-59Ans. (c)

IES-60. Assertion (A): Buttress thread is a modified square thread profile which is employed on the lead screw of machine tools. **[IES-2001]**
Reason (R): Frequent engagement and disengagement of lead screw for automatic feed is not possible with perfect square threads, therefore, the square profile has to be modified.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-60Ans. (d)

IES-61. The following parameters are to be calculated while designing screw jack.
1. Core diameter of screw 2. Torque required to rotate the screw
3. Principal stresses 4. Height of the nut [IES-2000]
The correct sequence of the calculation of these parameters is
(a) 1, 2, 4, 3 (b) 1, 2, 3, 4 (c) 2, 1, 3, 4 (d) 2, 1, 4, 3

IES-61Ans. (b)

IES-62. While designing a screw in a screw jack against buckling failure, the end conditions for the screw are taken as [IES-1995]
(a) Both the ends fixed (b) both the ends hinged
(c) One end fixed and other end hinged (d) one end fixed and the other end free.

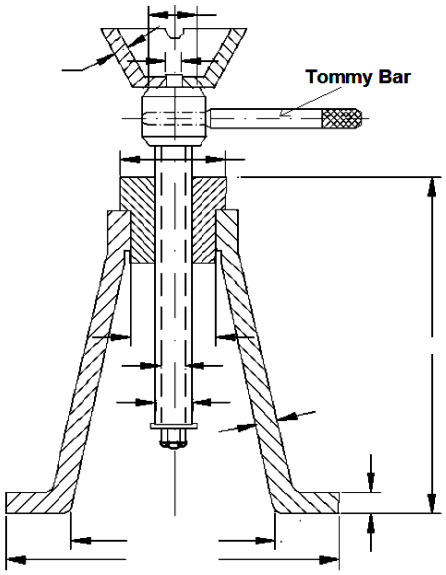
IES-62Ans. (d) The screw is considered to be a strut with lower end fixed and load end free

IES-63. Assertion (A): The load placed at the top of the screw in a mechanical screw jack is prevented from rotation by providing a swivelling mechanism. **[IES-1993]**
Reason (R): When the screw in a mechanical screw jack rotates, the load kept on top of it moves axially up or down.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-63Ans. (d) In this case A is false but R is true.

IES-64. The diameter of tommy bar for a screw jack is designed for [IES-1999]
(a) Bending moment due to effort applied
(b) Torque on the tommy bar due to effort applied
(c) A percentage of axial loads
(d) Some axial loads coupled with transverse loads

IES-64Ans. (a)



(a) Enhance the load carrying capacity of the jack
(b) Reduce the effort needed for lifting the working load
(c) Reduce the value of frictional torque required to be countered for lifting the load
(d) Prevent the rotation of load being lifted.

IES-65Ans. (d)

IES-66. Under service conditions involving jarring, vibration and pulsation of the working load, the bolt of choice would [IES 2007]
(a) short bolt with high rigidity (b) long bolt with increased elasticity
(c) Bolt with a dished washer (d) bolt with castle nut

IES-66Ans. (d)

IES-67. If P is the pitch of a square thread, then the depth of thread d is given by
(a) 0.5 P (b) P (c) 1.5 P (d) 2.0 P

IES-67Ans. (a)

IES-68. The frictional torque for square thread at mean radius while raising load is given by [IES-1993]
(W = load; R_o = Mean Radius; φ = Angle of friction; α = Helix angle)
$(a) WR_o \tan(\phi-\alpha)$ $(b) WR_o \tan(\phi+\alpha)$ $(c) WR_o \tan\alpha$ $(d) WR_o \tan\phi$

IES-68Ans. (b)

Self locking screw

IES-69. What is the efficiency of a self-locking power screw? [IES-2006; 1997]
(a) 70% (b) 60% (c) 55% (d) < 50 %

IES-69Ans. (d) We know that the frictional torque for square thread at mean radius while raising load is given by $WR_o \tan(\phi-\alpha)$
Where: (W = load; R_o = Mean Radius; ϕ = Angle of friction; α = Helix angle)
For self locking, angle of friction should be greater than helix angle of screw So that $WR_o \tan(\phi-\alpha)$ will become positive. i.e. we have to give torque to lowering the load.

IES-70. To ensure self-locking in a screw jack it is essential that helix angle is
(a) Larger than friction angle (b) smaller than friction angle. **[IES-1996]**
(c) Equal to friction angle (d) such as to give maximum efficiency in lifting.

IES-70Ans. (b)

Efficiency of screw

IES-71. The maximum efficiency of a screw jack having square threads with friction angle φ is [IES 2007]
(a) $\dfrac{1-\tan(\varphi/2)}{1+\tan(\varphi/2)}$ (b) $\dfrac{1-\tan\varphi}{1+\tan\varphi}$
(c) $\dfrac{1-\sin\varphi}{1+\sin\varphi}$ (d) $\dfrac{1-\sin(\varphi/2)}{1+\sin(\varphi/2)}$

IES-71Ans. (c)

IES-72. Assertion (A): The maximum efficiency $\left(\eta=\dfrac{1-\sin\phi}{1+\sin\phi}\right)$ of a screw jack is same, where ϕ is the friction angle, for both motion up and motion down the plane.
Reason (R): The condition for the maximum efficiency for motion up and motion down the plane is same, given by $\alpha=\dfrac{\pi}{4}-\dfrac{\phi}{2}$ where α = helix angle. **[IES-2003]**

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-72Ans. (a)

IES-73. A screw jack is said to be self-locking if its efficiency is [IES-2002]
(a) Less than 50% (b) equal to 50% (c) more than 50% (d) 100%

IES-73Ans. (a)

IES-74. Which one of the following is the value of helix angle for maximum efficiency of a square threaded screw? [$\phi = \tan^{-1}\mu$] [IES-2004]
(a) $45^o + \phi$ (b) $45^o - \phi$ (c) $45^o - \phi/2$ (d) $45^o + \phi/2$

IES-74Ans. (c)

Collar friction

IES-75. Stresses in a screw thread are estimated by considering the thread to be:
(a) Long cantilever beam projecting from the pitch cylinder **[IES-2006]**
(b) Long cantilever beam projecting from the root cylinder
(c) Short cantilever beam projecting from the root cylinder
(d) Short cantilever beam projecting from the pitch cylinder

IES-75Ans. (c)

Q.20. A power screw of 32 mm nominal diameter and 5 mm pitch is acted upon by an axial load *of* 12 kN. Permissible thread bearing pressure is 6 MPa; considering bearing action between the threads in engagement, what is the number of threads in engagement with the screw? [IES-2009]
(a) 6 (b) 7 (c) 9 (d) 10

20. Ans. (c)

Previous 20-Years IAS Questions

Uniform wear theory

IAS-1. The frictional torque transmitted in a flat pivot bearing, assuming uniform wear, is [IAS-2002]
(a) μWR (b) $\frac{3}{4}\mu WR$ (c) $\frac{2}{3}\mu WR$ (d) $\frac{1}{2}\mu WR$

(Where μ = Coefficient of friction; W = Load over the bearing; R = Radius of bearing)

IAS-1Ans. (d) Use frictional clutch formula.

$$T = \frac{\mu W}{4}(D+d),\ d = 0 \ \text{and}\ D = 2R \ \text{gives}\ T = \frac{\mu \pi R}{2}$$

Belt and Chain drives

IAS-2. A pulley and belt in a belt drive from a [IAS-2001]
(a) Cylindrical pair (b) turning pair (c) rolling pair (d) sliding pair

IAS-2Ans. (c)

IAS-3. Crushed ore is dropped on a conveyor belt at the rate of 300 kg/s. The belt moves at speed of 2 m/s. The net force acting on the belt that keeps it moving at the same speed is [IAS-2001]

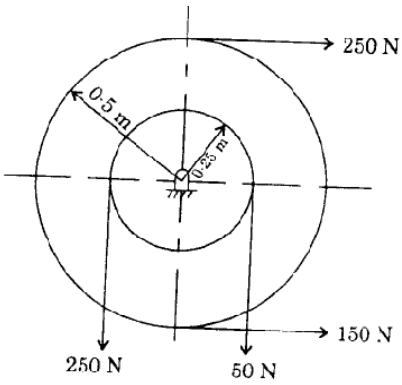
(a) 30 N (b) 60 N (c) 300 N (d) 600 N

IAS-3Ans. (d) Force = $\frac{d}{dt}(mv) = \frac{dm}{dt} \times v = 300 \times 2 = 600\,N$

Belt tension

IAS-4. A Differential pulley is subjected to belt tensions as shown in the diagram. The resulting force and moment when transferred to the centre of the pulley are, respectively

(a) 400 N and 0 Nm
(b) 400 N and 100 Nm
(c) 500 N and 0 Nm
(d) 500 N and 100 Nm



[IAS-2003]

IAS-4Ans. (c)

$F_y = 300$ N

Resultant force at the centre ↳ $F_x = 400$ N

$\Rightarrow \quad \sqrt{300^2 + 400^2} = 500$N

Resultant moment due to horizontal force
$= (250 - 150) \times 0.5 = 50$ N-m (clockwise)

and Resultant moment due to vertical force
$= (250 - 50) \times 0.25 = 50$ N-m (Anticlockwise)

$\therefore \quad$ Net moment $= 50$ N $- 50$ N $= 0$

Selection of V-belt drive

IAS-5. A 50 kW motor using six V belts is used in a pulp mill. If one of the belts breaks after a month of continuous running, then [IAS 1994]

(a) The broken belt is to be replaced by a similar belt
(b) All the belt are to be replaced
(c) The broken belt and two adjacent belts are to be replaced
(d) The broken belt and one adjacent belt are to be replaced

IAS-5Ans. (b)

Types of power screw

IAS-6. Match List I with List II and select the correct answer using the code given below the Lists: [IAS-2007]

List I (Type of Thread)	List II (Use)
A. Square thread	1. Used in vice
B. Acme thread	2. Used in lead screw
C. Buttress thread	3. Used in screw jack
D. Trapezoidal thread	4. Used in power transmission devices in machine tool

Code: A B C D A B C D

(a) 2 3 4 1 (b) 2 3 1 4
(c) 3 2 1 4 (d) 3 2 4 1

IAS-6Ans. (c)

3. Design of Power Transmission System

Objective Questions (IES, IAS, GATE)

Previous 20-Years GATE Questions

Spur gear

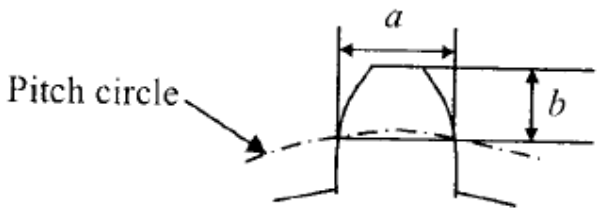
GATE-1. Match the type of gears with their most appropriate description. [GATE-2008]

Type of gear	Description
P Helical	1. Axes non parallel and intersecting
Q Spiral	2. Axes parallel and teeth are inclined to the axis
R Hypoid	3. Axes parallel and teeth are parallel to the axis
S Rack and pinion	4. Axes are perpendicular and intersecting, and teeth are inclined to the axis
	5. Axes are perpendicular and used for large speed reduction
	6. Axes parallel and one of the gears has infinite radius

(a) P-2, Q- 4, R- 1, S- 6 (c) P-2, Q- 6, R- 4, S- 2
(b) P-1, Q- 4, R- 5, S- 6 (d) P-6, Q- 3, R- 1, S- 5

GATE-1Ans. (a)

GATE-2. One tooth of a gear having 4 module and 32 teeth is shown in the figure. Assume that the gear tooth and the corresponding tooth space make equal intercepts on the pitch circumference. The dimensions *'a'* and *'b'*, respectively, are closest to [GATE-2008]



(a) 6.08 mm, 4 mm (b) 6.48 mm, 4.2 mm
(c) 6.28 mm, 4.3 mm (d) 6.28 mm, 4.1

GATE-2Ans. (a)

Classification of Gears

GATE-3. Match the following **[GATE-2004]**

Type of gears	**Arrangement of shafts**
P. Bevel gears	**1. Non-parallel off-set shafts**
Q. Worm gears	**2. Non-parallel intersecting shafts**
R. Herringbone gears	**3. Non-parallel non-intersecting shafts**
S. Hypoid gears	**4. Parallel shafts**

(a) P-4 Q-2 R-1 S-3 (b) P-2 Q-3 R-4 S-1
(c) P-3 Q-2 R-1 S-4 (d) P-1 Q-3 R-4 S-2

GATE-3Ans. (b)

Pitch point

GATE-4. In spur gears, the circle on which the involute is generated is called the
(a) Pitch circle (b) clearance circle **[GATE-1996]**
(c) Base circle (d) addendum circle

GATE-4Ans. (a)

Minimum Number of Teeth

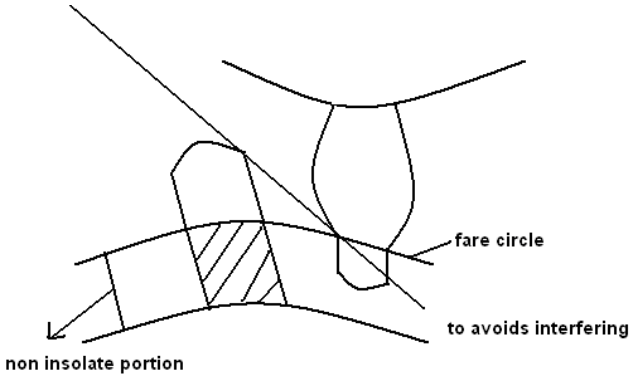
GATE-5. The minimum number of teeth on the pinion to operate without interference in standard full height involute teeth gear mechanism with 20° pressure angle is **[GATE-2002]**
(a) 14 (b) 12 (c) 18 (d) 32

GATE-5Ans. (c)

Interference

GATE-6 Tooth interference in an external in volute spur gear pair can be reduced by **[GATE-2010]**
(a) Decreasing center distance between gear pair
(b) Decreasing module
(c) Decreasing pressure angle
(d) Increasing number of gear teeth

GATE-6Ans. (d)



There are several ways to avoid interfering:
i. Increase number of gear teeth
ii. Modified involutes

iii. Modified addendum
iv. Increased centre distance

GATE-7. Interference in a pair of gears is avoided, if the addendum circles of both the gears intersect common tangent to the base circles within the points of tangency. [GATE-1995]

(a) True (b) False
(c) Insufficient data (d) None of the above

GATE-7Ans. (a)

GATE-8. Twenty degree full depth involute profiled 19-tooth pinion and 37-tooth gear are in mesh. If the module is 5 mm, the centre distance between the gear pair will be [GATE-2006]

(a) 140 mm (b) 150 mm
(c) 280 mm (d) 300 mm

GATE-8Ans. (a)

$$\text{Centre distance} = \frac{D_1 + D_2}{2} = \frac{mT_1 + mT_2}{2} = \frac{5(19+37)}{2} = 140\text{mm}$$

Beam Strength of Gear Tooth

GATE-9. A spur gear has a module of 3 mm, number of teeth 16, a face width of 36 mm and a pressure angle of 20°. It is transmitting a power of 3 kW at 20 rev/s. Taking a velocity factor of 1.5, and a form factor of 0.3, the stress in the gear tooth is about [GATE-2008]

(a) 32 MPa (b) 46 MPa
(c) 58 MPa (d) 70MPa

GATE-9Ans. (c)

Statement for Linked Answer GATE-10 and GATE-11:
A 20° full depth involute spur pinion of 4 mm module and 21 teeth is to transmit 15 kW at 960 rpm. Its face width is 25 mm.

GATE-10. The tangential force transmitted (in N) is [GATE -2009]

(a) 3552 (b) 261 1 (c) 1776 (d) 1305

GATE-10Ans. (a)

GATE-11. Given that the tooth geometry factor is 0.32 and the combined effect of dynamic load and allied factors intensifying the stress is 1.5; the minimum allowable stress (in MPa) for the gear material is [GATE -2009]

(a) 242.0 (b) 166.5 (c) 121.0 (d) 74.0

GATE-11Ans. (b)

Simple Gear train

Note: - Common Data for GATE-12 & GATE-13.
A gear set has a opinion with 20 teeth and a gear with 40 teeth. The pinion runs at 0 rev/s and transmits a power of 20 kW. The teeth are on the 20° full –depth system and have module of 5 mm. The length of the line of action is 19 mm.

GATE-12. The center distance for the above gear set in mm is [GATE-2007]

(a) 140 (b) 150 (c) 160 (d) 170.

GATE-12Ans. (b)

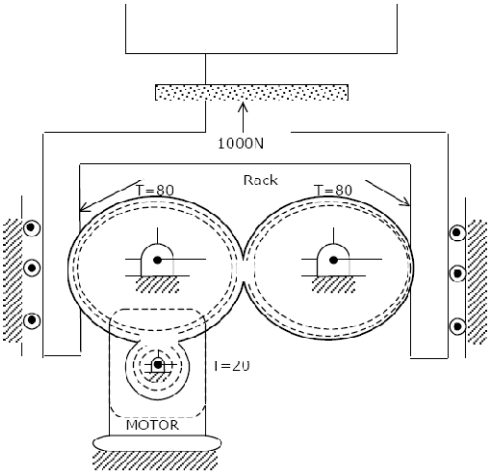
GATE-13 The contact ratio of the contacting tooth [GATE-2007]
(a) 1.21 (b) 1.25 (c) 1.29 (d) 1.33
GATE-13Ans. (c)

GATE-14. The resultant force on the contacting gear tooth in N is: [GATE-2007]
(a) 77.23 (b) 212.20 (c) 225.80 (d) 289.43
GATE-14Ans. (c)

Compound gear train

Data for GATE-15 & GATE-16 are given below. Solve the problems and choose correct answers.

A compacting machine shown in the figure below is used to create a desired thrust force by using a rack and pinion arrangement. The input gear is mounted on tile motor shaft. The gears have involute teeth of 2 mm module.



GATE-15. If the drive efficiency is 80%, then torque required on the input shaft to create 1000 N output thrust is [GATE-2004]
(a) 20 Nm (b) 25 Nm (c) 32 Nm (d) 50 Nm
GATE-15Ans. (b)

Given : Module m = 2, $\frac{D}{T} = 2$

$\therefore$ $D = 80 \times 2 = 160$ mm

$2F = 1000$, or $F = 500$ N

Let T_1 be the torque applied by motor.

T_2 be the torque applied by gear.

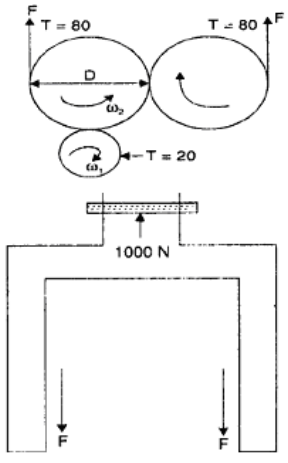
$\therefore$ Power transmission = 80%

Now, $T_1\omega_1 = \frac{2T_2 \times \omega_1}{0.8}$

or $T_1 = \frac{2 \times F \times (D/2)}{0.8} \times \frac{\omega_1}{\omega_2}$

$= 2 \times 500 \times \frac{0.16}{2} \times \frac{1}{0.8} \times \frac{1}{4}$

$= 25\,\text{N} - \text{m}.$



GATE-16. If the pressure angle of the rack is 20°, then force acting along the line of action between the rack and the gear teeth is [GATE-2004]
(a) 250 N (b) 342 N (c) 532 N (d) 600 N
GATE-16Ans. (c)

$$P\cos\phi = F$$

$\therefore$ Force acting along the line of action,

$$P = \frac{F}{\cos\phi}$$

$$= \frac{500}{\cos 20^\circ}$$

$$= 532\text{N}$$

Reverted gear train

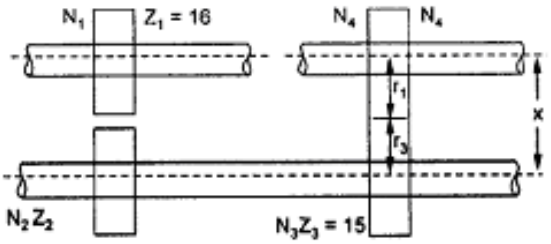
Data for GATE-17 & GATE-18 are given below. Solve the problems and choose correct answers.

The overall gear ratio in a 2 stage speed reduction gear box (with all spur gears) is 12. The input and output shafts of the gear box are collinear. The countershaft which is parallel to the input and output shafts has a gear (Z_2 teeth) and pinion (Z_3 = 15 teeth) to mesh with pinion (Z_1 = 16 teeth) on the input shaft and gear (Z_4 teeth) on the output shaft respectively. It was decided to use a gear ratio of 4 with 3 module in the first stage and 4 module in the second stage.

GATE-17. Z_2 and Z_4 are **[GATE-2003]**

(a) 64 and 45 (b) 45 and 64 (c) 48 and 60 (d) 60 and 48

GATE-17Ans. (a)



$$\text{Given, } \frac{N_1}{N_2} = 12, \frac{N_1}{N_2} = 4 = \frac{D_2}{D_1}$$

$$m_1 = 3,\ m_2 = 4$$

Now, $$\frac{D_1}{Z_1} = \frac{D_2}{Z_2}$$

$$\Rightarrow \quad \frac{Z_1}{Z_2} = \frac{D_1}{D_2} = \frac{N_2}{N_1} = \frac{1}{4}$$

$$\Rightarrow \quad Z_2 = Z_1 \times 4 = 64$$

$$\Rightarrow \quad 12 = \frac{D_4}{D_3}$$

$$\Rightarrow \quad \frac{D_4}{D_3} = 3$$

Also, $$\frac{Z_3}{Z_4} = \frac{D_3}{D_4}$$

$$\Rightarrow \quad Z_4 = Z_3 \frac{D_4}{D_3} = Z_3 \times 3 = 15 \times 3$$

$$= 45$$

GATE-18. The centre distance in the second stage is **[GATE-2003]**

(a) 90 mm (b) 120 mm (c) 160 mm (d) 240mm

GATE-18Ans. (b)

Now, $x = r_4 + r_3 = \frac{D_4 + D_3}{2}$

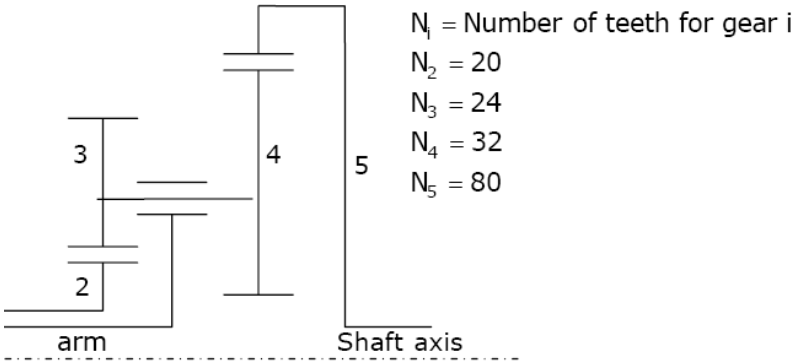
But $\frac{D_4}{Z_4} = \frac{D_3}{Z_3} = 4$

$\Rightarrow$ $D_4 = 180,\ D_3 = 60$

$\therefore$ $x = \frac{180 + 60}{2} = 120\text{mm}$

Epicyclic gear train

GATE-19. For the epicyclic gear arrangement shown in the figure, ω_2 = 100 rad/s clockwise (CW) and ω_{arm} = 80 rad/s counter clockwise (CCW). The angular velocity ω_5, (in rad/s) is [GATE-2010]



(a) 0 (b) 70 CW (c) 140 CCW (d) 140 CW

GATE-19Ans. (c)

	Arm	2	3	4	5
1.	0	$+x$	$\frac{-N_2}{N_3}x$	$\frac{-N_2}{N_3}x$	$\frac{-N_4}{N_5}\times\frac{N_2}{N_3}x$
2.	y	y	y	y	y
	y	x + y	$y - \frac{N_2}{N_3}x$		$y - \frac{N_4}{N_5}\times\frac{N_2}{N_3}x$

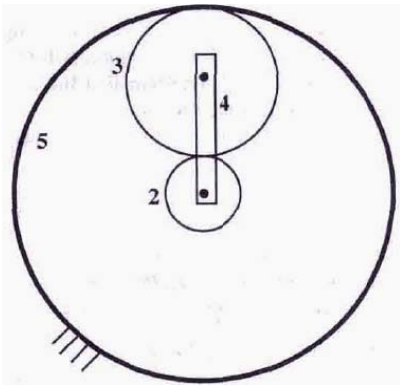
$x + y = 100$ (cw)

$y = -80$ (ccw)

$Speed\ of\ Gear\ (W_5) = -80 - \frac{32}{80}\times\frac{20}{24}\times 180 = -140 \quad = 140$ (ccw)

GATE-20. An epicyclic gear train is shown schematically in the adjacent figure. The sun gear 2 on the input shaft is a 20 teeth external gear. The planet gear 3 is a 40 teeth external gear. The ring gear 5 is a 100 teeth internal gear. The ring gear 5 is fixed and the gear 2 is rotating at 60 rpm (ccw = counter-clockwise and cw = clockwise).
The arm 4 attached to the output shaft will rotate at

(a) 10 rpm ccw
(b) 10 rpm ccw
(c) 12 rpm cw
(d) 12 rpm ccw

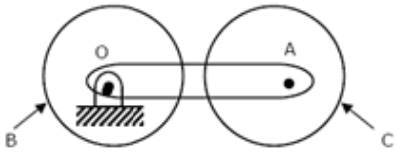


[GATE -2009]

GATE-20Ans. (a)

GATE-21 The arm OA of an epicyclic gear train shown in figure revolves counter clockwise about O with an angular velocity of 4 rad/s. Both gears are of same size. Tire angular velocity of gear C, if the sun gear B is fixed, is
[GATE-1995]

(a) 4 rad / sec
(b) 8 rad / sec
(c) 10 rad / sec
(d) 12 rad / sec



GATE-21Ans. (b)

Explanation

	Arm A	B	C
Fix arm A			
Give one rotation to B	0	1	-1
Multiply by x	0	+x	-x
Add y	y	X+ y	y-x

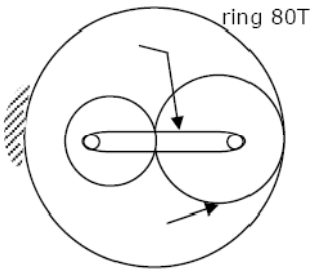
B is fixed, therefore $x + y = 0$

$y =$ rad/sec(ccw)

$\Rightarrow$ $x = -4$ rad/sec(cw)

Angular velocity of gear $C = y - x = 4 - (-4) = 8$ rad/s

GATE-22.The sun gear in the figure is driven clockwise at 100 rpm. The ring gear is held stationary.
For the number of teeth shown on the gears, the arm rotates at
(a) 0 rpm (b) 20 rpm
(c) 33.33 rpm (d) 66.67 rpm



[GATE-2001]

GATE-22Ans. (b)

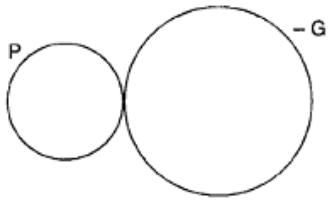
Arm	Sun	Planet	Ring
+1	+1	+1	+1
0	$\frac{80}{30}\times\frac{30}{20}$	$-\frac{80}{30}$	−1
1	5	$-\frac{5}{3}$	0

For 5 Revolutions Of Sun, Arm rotates by 1

$\therefore$ for 100 revolutions of Sun, Arm rotates by $\frac{100}{5}=20$

GATE-23. Two mating spur gears have 40 and 120 teeth respectively. The pinion rotates at 1200 rpm and transmits a torque of 20 Nm. The torque transmitted by the gear is [GATE-2004]
(a) 6.6 Nm (b) 20 Nm (c) 40 Nm (d) 60Nm

GATE-23Ans. (d)



We know $\frac{N_P}{N_G}=\frac{T_G}{T_P}$

where, N_P = speed of pinion, N_G = speed of gear wheel

T_G = number of teeth of gear,

T_P = number of teeth of pinion

$\therefore \quad \frac{1200}{N_G}=\frac{120}{40}$

or $N_G = 400$ r.p.m

Since power transmitted by both gear will be equal

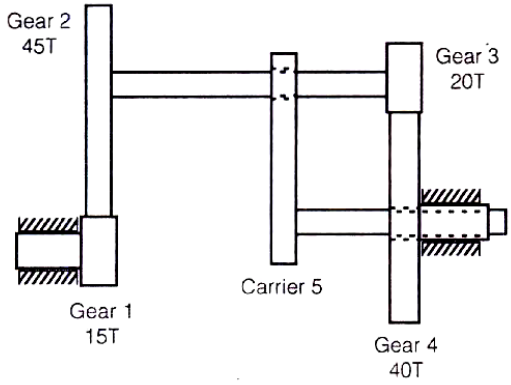
i.e. $T_P\omega_P = T_G\omega_G$

where, T_P = torque transmitted by pinion, T_G = torque transmitted by gear wheel

$\therefore \quad \frac{20\times 2\pi\times 1200}{60}=\frac{T_G\times 2\pi\times 400}{60}$

$\therefore$ torque transmitted by gear, $T_G = 60$N.m.

Common Data for GATE-24, GATE-25:
A planetary gear train has four gears and one carrier. Angular velocities of the gears are ω_1, ω_2, ω_3, and ω_4 respectively. The carrier rotates with angular velocity ω_5,



GATE-24. What is the relation between the angular velocities of Gear 1 and Gear 4? [GATE-2006]

GATE-24Ans. (a)

$$\frac{\omega_1 - \omega_5}{\omega_2 - \omega_5} = 3 \qquad \text{(with respect to arm 5 or carrier5)}$$

$$\frac{\omega_3 - \omega_5}{\omega_4 - \omega_5} = 2 \qquad \text{(with respect to carrier5)}$$

As, $\omega_3 - \omega_2$

$$\therefore \quad \frac{\omega_1 - \omega_5}{\omega_4 - \omega_5} = 6$$

GATE-25. For (ω_1 = 60 rpm clockwise (cw) when looked from the left, what is the angular velocity of the carrier and its direction so that Gear 4 rotates in counter clockwise (ccw) direction at twice the angular velocity of Gear 1 when looked from the left? [GATE-2006]

(a) 130 rpm, cw (b) 223 rpm, ccw
(c) 256 rpm, cw (d) 156 rpm, ccw

GATE-25Ans. (d)

$\omega_1 = 60\,\text{rpm (Clockwise)}$

$\omega_4 = 120\,\text{rpm (Counter clock wise)}$

$$\frac{60 - \omega_5}{-120 - \omega_5} = 6$$

$\therefore\ \omega_5 = -156\,\text{i.e. counter clockwise}$

Worm Gears

GATE-26. Large speed reductions (greater than 20) in one stage of a gear train are possible through [GATE-2002]

(a) Spur gearing (b) Worm gearing (c) Bevel gearing (d) Helical gearing

GATE-26Ans. (b)

GATE-27. A 1.5 kW motor is running at 1440 rev/min. It is to be connected to a stirrer running at 36 rev /min. The gearing arrangement suitable for this application is [GATE-2000]

(a) Differential gear (b) helical gear

GATE-28. To make a worm drive reversible, it is necessary to increase [GATE-1997]
(a) centre distance (b) worm diameter factor
(c) Number of starts (d) reduction ratio
GATE-28Ans. (c)

Previous 20-Years IES Questions

Spur gear

IES-1. The velocity ratio between pinion and gear in a gear drive is 2.3, the module of teeth is 2.0 mm and sum of number of teeth on pinion and gear is 99. What is the centre distance between pinion and the gear? [IES 2007]

(a) 49.5 mm (b) 99 mm (c) 148.5 mm (d) 198 mm

IES-1. Ans. (b) Centre distance = $\frac{D_1 + D_2}{2} = \frac{mT_1 + mT_2}{2} = \frac{m}{2}(T_1 + T_2) = \frac{2}{2} \times 99 = 99\text{mm}$

IES-2. Consider the following statements: [IES-2001]
When two gears are meshing, the clearance is given by the
1. Difference between dedendum of one gear and addendum of the mating gear.
2. Difference between total and the working depth of a gear tooth.
3. Distance between the bottom land of one gear and the top land of the mating gear.
4. Difference between the radii of the base circle and the dedendum circle.
Which of these statements are correct?
(a) 1, 2 and 3 (b) 2, 3 and 4 (c) 1, 3 and 4 (d) 1, 2 and 4
IES-2. Ans. (a)

IES-3. The working surface above the pitch surface of the gear tooth is termed as [IES-1998]
(a) Addendum (b) dedendum (c) flank (d) face
IES-3. Ans. (d)

IES-4. Match the following $14\frac{1}{2}^{o}$ composite system gears [IES-1992]

List I	List II
A. Dedendum	**1.** $\frac{2}{pd}$
B. Clearance	**2.** $\frac{0.157}{pd}$
C. Working depth	**3.** $\frac{1.157}{pd}$
D. Addendum	**4.** $\frac{1}{pd}$

Code:	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	4	3	2	1
(c)	3	2	1	4	(d)	3	1	2	4

IES-4. Ans. (c)

IES-5. Match List I with List II and select the correct answer using the codes given below the lists: [IES-1993]

List I (Standard tooth/arms)	List II (Advantages or disadvantages)
A. 20° and 25° systems	1. Results in lower loads on bearing
B. 14.5° stub-tooth system	2. Broadest at the base and strongest in bending
C. 25° Full depth system	3. Obsolete
D. 20° Full depth system	4. Standards for new applications

Code:	A	B	C	D		A	B	C	D
(a)	4	3	2	1	(b)	3	1	2	4
(c)	3	2	1	4	(d)	4	2	3	1

IES-5. Ans. (a)

IES-6. **Assertion (A):** When one body drives another by direct contact, their contact points must have equal components of velocity normal to the surfaces at the point of contact.

Reason (R): Two points in the same body must have the same component of velocity relative to the third body, in the direction of the line joining the two points. **[IES-1993]**

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-6Ans. (a)

Classification of Gears

IES-7. Match List I with List II and select the correct answer [IES-1996]

List I	List II
A. Helical gears	1. Non-interchangeable
B. Herring bone gears	2. Zero axial thrust
C. Worm gears	3. Quiet motion
D. Hypoid Gears	4. Extreme speed reduction

Codes:	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	3	2	1	4
(c)	3	1	4	2	(d)	3	2	4	1

IES-7Ans. (d)

IES-8. Match List-l (Type of Gears) with List-II (Characteristics) and select the correct answer using the code given below the Lists: [IES-2006]

List-I	List -II
A. Helical gearing	1. Zero axial thrust
B. Herringbone gearing	2. Non-inter-changeable
C. Worm gearing	3. Skew shafts
D. Hypoid gearing	4. Parallel shafts

	A	B	C	D		A	B	C	D
(a)	4	1	3	2	(b)	3	2	4	1
(c)	4	2	3	1	(d)	3	1	4	2

IES-8Ans. (a)

IES-9. Match List I with List II and select the correct answer using the code given below the Lists: [IES 2007]

List I	List II
A. Worm gear	1. Imposes no thrust load on the shaft
B. Spur gear	2. To transmit power between two non-intersecting shafts which are perpendicular to each other
C. Herringbone gear	3. To transmit power when the shafts are parallel
D. Spring level gear	4. To transmit power when the shafts are at right angles to one another

Code:	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	2	3	1	4
(c)	1	2	4	3	(d)	2	3	4	1

IES-9Ans. (b)

IES-10. Match List I (Type of Gear/Gear Train) with List II (Different Usage and Drive) and select the correct answer using the code given below the Lists: [IES-2005]

List I	List II
A Epicyclic gear train	1. Reduces end thrust
B. Bevel Gear	2. Low gear ratio
C. Worm-worm Gear	3. Drives non-parallel nonintersecting shafts
D. Herringbone Gear	4. Drives non-parallel intersecting shafts
	5. High gear ratio

	A	B	C	D		A	B	C	D
(a)	5	4	3	1	(b)	2	3	4	5
(c)	5	3	4	1	(d)	2	4	3	5

IES-10Ans. (a)

IES-11. Which type of gear is used for shaft axes having an offset? [IES-2004]

(a) Mitre gears (b) Spiral bevel gears
(c) Hypoid gears (d) Zerol gears

IES-11.Ans. (c)

IES-12. The gears employed for connecting two non-intersecting and non-parallel, i.e., non-coplanar shafts are [IES-2003; 2005]

(a) Bevel gears (b) Spiral gears (c) Helical gears (d) Mitre gears

IES-12.Ans. (b)

IES-13. When two shafts are neither parallel nor intersecting, power can be transmitted by using [IES-1998]

(a) A pair of spur gears (b) a pair of helical gears
(c) An Oldham's coupling (d) a pair of spiral gears

IES-13Ans. (d)

IES-14. In a single reduction, a large velocity ratio is required. The best transmission is [IES-1999]

(a) Spur gear drive (b) helical gear drive
(c) Bevel gear drive (d) worm gear drive

IES-14Ans. (a)

IES-15. Which one of the following pairs is not correctly matched? [IES-1995]

(a) Positive drive .... Belt drive
(b) High velocity ratio .... Worm gearing
(c) To connect non-parallel and non- intersecting shafts .... Spiral gearing.

(d) Diminished noise and smooth operation .... Helical gears.

IES-15Ans. (a)

Mitres gear

IES-16. Mitre gears [IES-1992]

(a) spur-gears with gear ratio 1: 1

(b) Skew gears connecting non-parallel and nonintersecting shafts

(c) Bevel gears transmitting power at more than or less than 90°

(d) Bevel gears in which the angle between the axes is 90° and the speed ratio of the gears is 1: 1

IES-16Ans. (d)

IES-17. Match List-I (Gears) with List-II (Configurations) and select the correct answer using the codes given below the Lists: [IES-2003]

List-I (Gears)	List-II (Configurations)
A Spur	1. Connecting two non-parallel or intersecting but coplanar shafts
B. Bevel	2. Connecting two parallel and coplanar shafts with teeth parallel to the axis of the gear wheel
C. Helical	3. Connecting two parallel and coplanar shafts with teeth inclined to the axis of the gear wheel
D. Mitre	4. Connecting two shafts whose axes are mutually perpendicular to each other

Codes:	A	B	C	D		A	B	C	D
(a)	2	4	3	1	(b)	3	1	2	4
(c)	2	1	3	4	(d)	3	4	2	1

IES-17Ans. (c)

Pitch point

IES-18. Gearing contact is which one of the following? [IES 2007]

(a) Sliding contact

(b) Sliding contact, only rolling at pitch point

(c) Rolling contact

(d) Rolling and sliding at each point of contact

IES-18Ans. (b)

When pair of teeth touch at the pitch point ,they have for the instant pure rolling action. At any other position they have the slidingaction.

IES-19. When two spur gears having involute profiles on, their teeth engage, the line of action is tangential to the [IES-2003]

(a) Pitch circles

(b) Dedendum circles

(c) Addendum circles

(d) Base circles

IES-19Ans. (d)

Pressure angle

IES-20. What is the value of pressure angle generally used for involute gears? [IES-2006]

(a) 35° (b) 30° (c) 25 ° (d) 20°

IES-20Ans. (d)

IES-21. Consider the following, modifications regarding avoiding the interference between gears: [IES-2003]

1. The centre distance between meshing gears be increased
2. Addendum of the gear be modified
3. Teeth should be undercut slightly at the root
4. Pressure angle should be increased
5. Circular pitch be increased

Which of these are effective in avoiding interference?

(a) 1, 2 and 3 (b) 2, 3, 4 and 5 (c) 1, 4 and 5 (d) 3, 4 and 5

IES-21Ans. (b)

IES-22. An external gear with 60 teeth meshes with a pinion of 20 teeth, module being 6 mm. What is the centre distance in mm? [IES-2009]

(a) 120 (b) 180 (c) 240 (d) 300

IES-22Ans. (c)

$$\text{Centre distance in mm} = \frac{m}{2}(T_1 + T_2)$$

$$= \frac{6}{2}(60 + 20)$$

$$= 240 \text{ mm}$$

IES-23. Assertion (A): An involute rack with 20° pressure angle meshes with a pinion of 14.5° pressure angle. **[IES-2002]**

Reason (R): Such a matching is impossible.

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-23Ans. (d)

IES-24. Compared to gears with 20^0 pressure angle involute full depth teeth, those with 20^0 pressure angle and stub teeth have [IES 2007]

1. Smaller addendum. **2. Smaller dedendum.**
3. Smaller tooth thickness. **4. Greater bending strength.**

Which of the statements given above are correct?

(a) 1, 2 and 3 (b) 1, 2 and 4
(c) 1, 3 and 4 (d) 2, 3 and 4

IES-24Ans. (b)

IES-25. Consider the following statements: [IES-1999]

A pinion of $14\frac{1}{2}^o$ pressure angle and 48 involute teeth has a pitch circle diameter of 28.8 cm. It has

1. Module of 6 mm **2. Circular pitch of 18 mm**
3. Addendum of 6 mm **4. Diametral pitch of $\frac{11}{113}$**

Which of these statements are correct?

(a) 2 and 3 (b) 1 and 3 (c) 1 and 4 (d) 2 and 4

IES-25Ans. (b) Module = $\frac{d}{T} = \frac{288}{48} = 6\text{mm}$

Circular pitch $= \frac{\pi d}{T} = \pi \times 6 = 18.84$ mm ; addendum = 1 module = 6 mm

diametral pitch $= \frac{T}{d} = \frac{1}{6}$

Circular pitch = - = 1t X 6 = 18.84 mm

IES-26. Which of the following statements are correct? [IES-1996]

1. For constant velocity ratio transmission between two gears, the common normal at the point of contact must always pass through a fixed point on the line joining the centres of rotation of the gears.
2. For involute gears the pressure angle changes with change in centre distance between gears.
3. The velocity ratio of compound gear train depends upon the number of teeth of the input and output gears only.
4. Epicyclic gear trains involve rotation of at least one gear axis about some other gear axis.

(a) 1, 2 and 3 (b) 1, 3and 4 (c) 1, 2 and 4 (d) 2, 3 and 4

IES-26Ans. (c)

IES-27. Which one of the following is true for involute gears? [IES-1995]

(a) Interference is inherently absent
(b) Variation in centre distance of shafts increases radial force
(c) A convex flank is always in contact with concave flank
(d) Pressure angle is constant throughout the teeth engagement.

IES-27Ans. (d) For involute gears, the pressure angle is constant throughout the teeth engagement.

IES-28. In involute gears the pressure angle is [IES-1993]

(a) Dependent on the size of teeth (b) dependent on the size of gears
(c) Always constant (d) always variable

IES-28Ans. (c) The pressure angle is always constant in involute gears.

Minimum Number of Teeth

IES-29. Which one of the following statements is correct? [IES-2004]

Certain minimum number of teeth on the involute pinion is necessary in order to
(a) Provide an economical design (b) avoid Interference
(c) Reduce noise in operation (d) overcome fatigue failure of the teeth

IES-29Ans. (b)

IES-30. A certain minimum number of teeth is to be kept for a gear wheel

(a) So that the gear is of a good size **[IES-1999]**
(b) For better durability
(c) To avoid interference and undercutting
(d) For better strength

IES-30Ans. (c)

IES-31. In full depth $14\frac{1}{2}^{o}$ degree involute system, the smallest number of teeth in a pinion which meshes with rack with out interference is [IES-1992]

(a) 12 (b) 16 (c) 25 (d) 32

IES-32Ans. (d)

IES-33. Match List I with List II and select the correct answer using the codes given below the lists:

List I (Terminology)	List II (Relevant terms)
A. Interference	1. Arc of approach, arc of recess, circular pitch
B. Dynamic load on tooth	2. Lewis equation
C. Static load	3. Minimum number of teeth on pinion
D. Contract ratio	4. Inaccuracies in tooth profile

[IES-1995]

Codes:	A	B	C	D		A	B	C	D
(a)	3	4	1	2	(b)	1	2	3	4
(c)	4	3	2	1	(d)	3	4	2	1

IES-33Ans. (d)

IES-34 **Assertion (A):** When a pair of spur gears of the same material is in mesh, the design is based on pinion. **[IES-2002; 1993]**
Reason (R): For a pair of gears of the same material in mesh, the 'strength factor' of the pinion is less than that of the gear.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

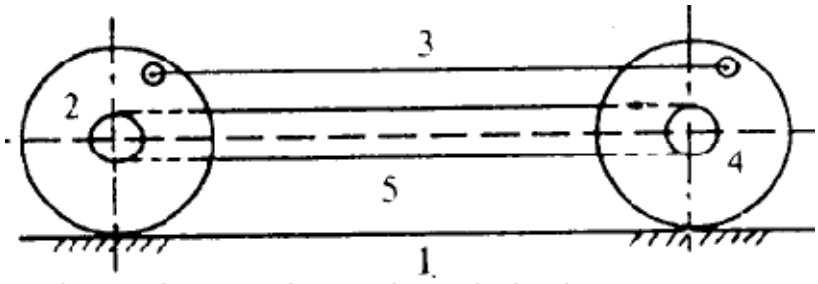
IES-34Ans. (a)

Cycloidal teeth

IES-35. The curve traced by a point on the circumference of a circle which rolls along the inside of affixed circle, is known as [IES-1992]
(a) Epicycloid (b) hypocycloid
(c) Cardiod (d) involute

IES-35Ans. (b)

IES-36



In the mechanism shown above, link 3 has [IES-2004]
(a) Curvilinear translation and all points in it trace out identical cycloids
(b) Curvilinear translation and all points in it trace out identical involutes
(c) Linear translation & all points in it trace out identical helices
(d) Linear translation & all points in it trace out identical ellipses

IES-36Ans. (a)

IES-37. A thin circular disc is rolling with a uniform linear speed, along a straight path on a plane surface. [IES-1994]
Consider the following statements in this regard:
1. All points on the disc have the same velocity.
2. The centre of the disc has zero acceleration.
3. The centre of the disc has centrifugal acceleration.

4. The point on the disc making contact with the plane surface has zero acceleration of these statements

(a) 1 and 4 are correct (b) 3 and 4 are correct
(c) 3 alone is correct (d) 2 alone is correct.

IES-37.Ans. (d)

Involute teeth

IES-38. In the case of an involute toothed gear, involute starts from [IES-1997]

(a) Addendum circle (b) dedendum circle
(c) Pitch circle (d) base circle

IES-38Ans. (b)

IES-39. Consider the following statements: [IES-2006]

1. A stub tooth has a working depth larger than that of a full-depth tooth.
2. The path of contact for involute gears is an arc of a circle.
Which of the statements given above is/are correct?

(a) Only 1 (b) Only 2 (c) Both 1 and 2 (d) Neither 1 nor 2

IES-39Ans. (d) 1. A stub tooth has a working depth lower than that of a full-depth tooth.
2. The path of contact for involute gears is a line.

IES-40. Consider the following statements regarding the choice of conjugate teeth for the profile of mating gears: [IES-1999]

1. They will transmit the desired motion
2. They are difficult to manufacture.
3. Standardisation is not possible
4. The cost of production is low.
Which of these statements are correct?

(a) 1, 2 and 3 (b) 1, 2 and 4 (c) 2, 3 and 4 (d) 1, 3 and 4

IES-40Ans. (a) Cost of production of conjugate teeth, being difficult to manufacture is high.

IES-41. Which one of the following is correct? [IES-2008]

When two teeth profiles of gears are conjugate, the sliding velocity between them

(a) Is always zero, all through the path of contact?
(b) Is zero, at certain points along the path of contact?
(c) Is never zero anywhere on the path of contact?
(d) Can be made zero by proper selection of profiles

IES-41Ans. (a)

Contact ratio

IES-42. Which one of the following is the correct statement? [IES 2007]

In meshing gears with involute gears teeth, the contact begins at the intersection of the

(a) Line of action and the addendum circle of the driven gear
(b) Line of action and the pitch circle of the driven gear
(c) Dedendum circle of the driver gear and the addendum circle of the driven gear
(d) Addendum circle of the driver gear and the pitch circle of the driven gear

IES-42Ans. (a)

IES-43. Common contact ratio of a pair of spur pinion and gear is [IES-2008]

(a) Less than 1·0 (b) equal to 1
(c) Between 2 and 3 (d) greater than 3

IES-43Ans. (c) The ratio of the length of arc of contact to the circular pitch is known as **contact ratio** i.e. number of pairs of teeth in contact. The contact ratio for gears is greater than one. Contact ratio should be at least 1.25. For maximum smoothness and quietness, the contact ratio should be between 1.50 and 2.00. High-speed applications should be designed with a face-contact ratio of 2.00 or higher for best results.

Interference

IES-44. Interference between an involute gear and a pinion can be reduced by which of the following? [IES-2008]
1. Increasing the pressure angle of the teeth in the pair, the number of teeth remaining the same.
2. Decreasing the addendum of the gear teeth and increasing the same for the pinion teeth by the corresponding amount.
Select the correct answer using the code given below:
(a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2

IES-44Ans. (c)

IES-45. In gears, interference takes place when [IES-1993]
(a) The tip of a tooth of a mating gear digs into the portion between base and root circles
(b) Gears do not move smoothly in the absence of lubrication
(c) Pitch of the gear is not same
(d) gear teeth are undercut

IES-45Ans. (a) In gears, interference takes place when the tip of a tooth of a mating gear digs into the portion between base .and root circle.

IES-46. An involute pinion and gear are in mesh. If both have the same size of addendum, then there will be an interference between the [IES-1996]
(a) Tip of the gear tooth and flank of pinion.
(b) Tip of the pinion and flank of gear.
(c) Flanks of both gear and pinion.
(d) Tips of both gear and pinion.

IES-46Ans. (a)

IES-47. Interference between the teeth of two meshing involute gears can be reduced or eliminated by [IES 2007]
1. Increasing the addendum of the gear teeth and correspondingly reducing the addendum of the pinion.
2. Reducing the pressure angle of the teeth of the meshing gears.
3. Increasing the centre distance
Which of the statements given above is/are correct?
(a) 1 and 2 (b) 2 and 3
(c) 1 only (d) 3 only

IES-47Ans. (d)

IES-48. Consider the following statements: [IES-2002]
A 20^{o} stub tooth system is generally preferred in spur gears as it results in
1. Stronger teeth
2. Lesser number of teeth on the pinion
3. Lesser changes of surface fatigue failure
4. Reduction of interference
Which of the above statements are correct?

(a) 1, 2 and 4 (b) 3 and 4 (c) 1 and 3 (d) 1, 2, 3 and 4

IES-48Ans. (a)

IES-49. Match List-I with List-II and select the correct answer using the codes given below the lists: [IES-2001]

List-I	List-II
A. Undercutting	1. Beam strength
B. Addendum	2. Interference
C. Lewis equation	3. Large speed reduction
D. Worm and wheel	4. Intersecting axes
	5. Module

Codes:	A	B	C	D		A	B	C	D
(a)	2	5	1	3	(b)	1	5	4	3
(c)	1	3	4	5	(d)	2	3	1	5

IES-49Ans. (a)

IES-50. Which one of the following pairs is correctly matched? [IES-1999]

(a) Governors ... Interference
(b) Gears .....Hunting
(c) Klein's construction.... Acceleration of piston
(d) Cam .....Pinion

IES-50Ans. (c)

IES-51. Consider the following characteristics: [IES-1998]

1. Small interference 2. Strong tooth.
3. Low production cost 4. Gear with small number of teeth.

Those characteristics which are applicable to stub 20° involute system would include

(a) 1 alone (b) 2, 3 and 4 (c) 1, 2 and 3 (d) 1, 2, 3 and 4

IES-51Ans. (b) Involute system is very interference prone.

IES-52. The motion transmitted between the teeth of two spur gears in mesh is generally [IES-1999]

(a) Sliding (b) rolling
(c) Rotary (d) party sliding and partly rolling

IES-52Ans. (b)

Beam Strength of Gear Tooth

IES-53. In heavy-duty gear drives, proper heat treatment of gears is necessary in order to: [IES-2006]

(a) Avoid interference
(b) Prevent noisy operation
(c) Minimize wear of gear teeth
(d) Provide resistance against impact loading on gear teeth

IES-53Ans. (c)

IES-54. Consider the following statements pertaining to the basic Lewis equation for the strength design of spur gear teeth: [IES-2005]

1. Single pair of teeth participates in power transmission at any instant.
2. The tooth is considered as a cantilever beam of uniform strength.
3. Loading on the teeth is static in nature.
4. Lewis equation takes into account the inaccuracies of the tooth profile.
5. Meshing teeth come in contract suddenly.

Which of the statements given above are correct?
(a) 1, 3, 4 and 5 (b) 1,2, 3 and 4 (c) 1, 2 and 3 (d) 2, 4 and 5

IES-54Ans. (c)

IES-55. **Assertion (A):** The Lewis equation for design of gear tooth predicts the static load capacity of a cantilever beam of uniform strength.
Reason (R): According to law of gears interchangeability is possible only when gears have same pressure angle and same module. **[IES-2008]**
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-55Ans. (b) The beam strength of gear teeth is determined from an equation (known as Lewis equation) and the load carrying ability of the toothed gears as determined by this equation gives satisfactory results. In the investigation, Lewis assumed that as the load is being transmitted from one gear to another, it is all given and taken by one tooth, because it is not always safe to assume that the load is distributed among several teeth.

Notes: (*i*) The Lewis equation is applied only to the weaker of the two wheels (*i.e.* pinion or gear).

(*ii*) When both the pinion and the gear are made of the same material, then pinion is the weaker.

(*iii*) When the pinion and the gear are made of different materials, then the product of $(\sigma_w \times y)$ *or* $(\sigma_o \times y)$ is the deciding factor. The Lewis equation is used to that wheel for which $(\sigma_w \times y)$ *or* $(\sigma_o \times y)$ is less.

IES-56. **In the formulation of Lewis equation for toothed gearing, it is assumed that tangential tooth load F_t, acts on the** **[IES-1998]**
(a) Pitch point (b) tip of the tooth
(c) Root of the tooth (d) whole face of the tooth

IES-56Ans. (b)

IES-57. **Assertion (A):** The Lewis equation for gear tooth with involute profile predicts the static load capacity of cantilever beam of uniform strength. **[IES-1994]**
Reason (R): For a pair of meshing gears with involute tooth profile, the pressure angle and module must be the same to satisfy the condition of inter-changeability.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-57Ans. (c) For a pair of meshing gears with involute tooth profile, the pressure angle and module must be the same to satisfy the condition of inter-changeability it is not correct. Due to law of gearing.

IES-58. **The dynamic load on a gear is due to** **[IES-2002]**
1. Inaccuracies of tooth spacing
2. Irregularities in tooth profile
3. Deflection of the teeth under load
4. Type of service (i.e. intermittent, one shift per day, continuous per day).
Which of the above statements are correct?
(a) 1. 2 and 3 (b) 2, 3 and 4 (c) 1, 3 and 4 (d) 1, 2 and 4

IES-58Ans. (a)

IES-59. Consider the following statements:
The form factor of a spur gear tooth depends upon the **[IES-1996]**
1. Number of teeth **2. Pressure angle**
3. Addendum modification coefficient **4. Circular pitch**
Of these correct statements are
(a) 1 and 3 (b) 2 and 4 (c) 1, 2 and 3 (d) 1 and 4

IES-59Ans. (c)

IES-60. Assertion (A): If the helix angle of a helical gear is increased, the load carrying capacity of the tooth increases. **[IES-1996]**
Reason (R): The form factor of a helical gear increases with the increasing in the helix angle.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-61Ans. (a)

IES-62. Match List I with List II and select the correct answer using the codes given below the Lists:

List I	**List II**
A. Unwin's formula	**1. Bearings**
B. Wahl factor	**2. Rivets**
C. Reynolds's equation	**3. Gears**
D. Lewis form factor	**4. Springs**

[IES-2000]

Code:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	1	4	2	3	(b)	2	3	1	4
(c)	1	3	2	4	(d)	2	4	1	3

IES-62Ans. (d)

IES-62. A spur gear transmits 10 kW at a pitch line velocity of 10 m/s; driving gear has a diameter of 1.0 m. Find the tangential force between the driver and the follower, and the transmitted torque respectively. **[IES-2009]**
(a) 1 kN and 0.5 kN-m (b) 10 kN and 5 kN-m
(c) 0.5 kN and 0.25 kN-m (d) 1 kN and 1 kN-m

IES-62Ans. (a) Power transmitted = Force × Velocity

$$\Rightarrow \quad 10\times10^3 = \text{Force}\times 10$$

$$\Rightarrow \quad \text{Force} = \frac{10\times10^3}{10} = 1000 \text{ N/m}$$

$$\text{Torque Transmitted} = \text{Force}\times\frac{\text{diameter}}{2}$$

$$= 1000\times\frac{1}{2} = 1000\times 0.5$$

$$= 500\,\text{N}-\text{m} = 0.5 \text{ kN}-\text{m}$$

Wear Strength of Gear Tooth

IES-63. The limiting wear load of spur gear is proportional to (where E_p = Young's modulus of pinion material; E_g = Young's modulus of gear material) **[IES-1997]**

(a) $\left(E_p + E_g\right)^{-1}$ (b) $\left(\frac{E_p + E_g}{E_p E_g}\right)$ (c) $\left(1 + \frac{E_p}{E_g}\right)$ (d) $\left(1 + \frac{E_g}{E_p}\right)$

IES-63Ans. (b)

Gear Lubrication

IES-64. Match List I (Types of gear failure) with List II (Reasons) and select the correct answer using the codes given below the Lists [IES-2004]

List I	List II
A. Scoring	1. Oil film breakage
B. Pitting	2. Yielding of surface under heavy loads
C. Scuffing	3. Cyclic loads causing high surface stress
D. Plastic flow	4. Insufficient lubrication

	A	B	C	D		A	B	C	D
(a)	2	1	3	4	(b)	2	3	4	1
(c)	4	3	1	2	(d)	4	1	3	2

IES-64Ans. (b)

Simple Gear train

IES-65. In a simple gear train, if the number of idler gears is odd, then the direction or motion of driven gear will [IES-2001]

(a) Be same as that of the driving gear
(b) Be opposite to that of the driving gear
(c) Depend upon the number of teeth on the driving gear
(d) Depend upon the total number of teeth on all gears of the train

IES-65Ans. (a)

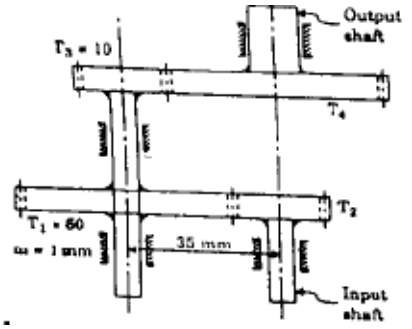
IES-66. The gear train usually employed in clocks is a [IES-1995]

(a) Reverted gear train (b) simple gear train
(c) Sun and planet gear (d) differential gear.

IES-66Ans. (a)

IES-67. In the figure shown above, if the speed of the input shaft of the spur gear train is 2400 rpm and the speed of the output shaft is 100 rpm, what is the module of the gear 4?

(a) 1.2 (b) 1.4
(c) 2 (d) 2.5



[IES-2005]

IES-67Ans. (b)

$$\frac{mT_2 + mT_1}{2} = 35$$

or $T_2 = 10$

$$N_1 = -N_i \times \frac{T_2}{T_1} = N_3$$

$$N_4 = \frac{-N_3 T_3}{T_4} = +N_i \times \frac{T_2}{T_1} \times \frac{T_3}{T_4} \text{ or } 100 = 2400 \times \frac{10}{60} \times \frac{10}{T_4} \text{ or } T_4 = 40$$

$$\frac{m'T_3 + m'T_4}{2} = 35 \text{ or } m' = \frac{70}{(40+10)} = 1.4$$

IES-68 In a machine tool gear box, the smallest and largest spindles are 100 rpm and 1120 rpm respectively. If there are 8 speeds in all, the fourth speed will be [IES-2002]

(a) 400 rpm (b) 280 rpm (c) 800 rpm (d) 535 rpm

IES-68Ans. (b)

IES-69. A fixed gear having 200 teeth is in mesh with another gear having 50 teeth. The two gears are connected by an arm. The number of turns made by the smaller gear for one revolution of arm about the centre of the bigger gear is [IES-1996]

(a) $\frac{2}{4}$ (b) 3 (c) 4 (d) 5

IES-69Ans. (d) 1 + 200/50 = 1 + 4 = 5

Compound gear train

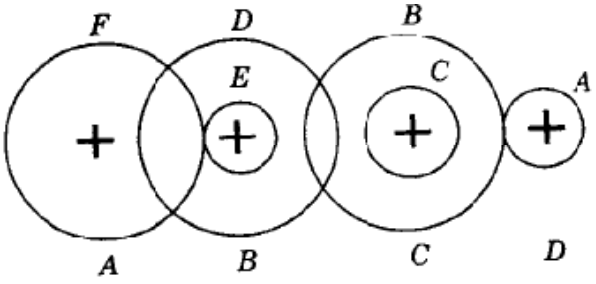
IES-70 The velocity ratio in the case of the compound train of wheels is equal to [IES-2000]

(a) $\frac{\text{No. of teeth on first driver}}{\text{No. of teeth on last follower}}$ (b) $\frac{\text{No. of teeth on last follower}}{\text{No. of teeth on first driver}}$

(c) $\frac{\text{Product of teeth on the drivers}}{\text{Product of teeth on the followers}}$ (d) $\frac{\text{Product of teeth on the followers}}{\text{Product of teeth on the drivers}}$

IES-70Ans. (d)

IES-71. Consider the gear train shown in the given figure and table of gears and their number of teeth.



Gear :A B C D E F
No of teeth:20 50 25 75 26 65

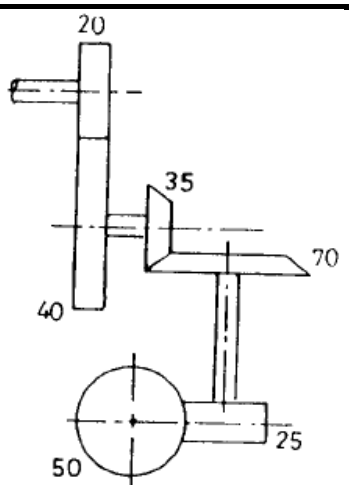
[IES-1999]

Gears BC and DE are moulded on parallel shaft rotating together. If the speed of A is 975 r.p.m., the speed of F will be

IES-71Ans. (b)

Speed ratio $\frac{N_F}{N_A} = \frac{T_A \times T_C \times T_E}{T_B \times T_D \times T_F} = \frac{20 \times 25 \times 26}{50 \times 75 \times 65} = \frac{4}{75}$ $\quad or\ N_F = 975 \times \frac{4}{75} = 52\,rpm$

IES-72. A compound train consisting of spur, bevel and spiral gears are shown in the given figure along with the teeth numbers marked against the wheels. Over-all speed ratio of the train is



(a) 8

(b) 2

(c) $\frac{1}{2}$

(d) $\frac{1}{8}$

[IES-1996]

IES-72Ans. (a)

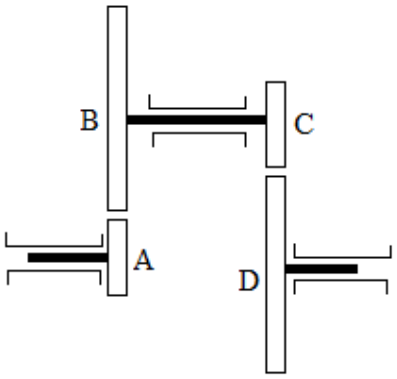
Elements of higher pair like follower in cam is under the action of gravity or spring force .

$$\text{Train value} = \frac{\text{speed of lost driven or follower}}{\text{speed of the first gear}}$$

$$\text{Train value} = \frac{\text{product of no.of teeth no the drives}}{\text{product of no.of teeth on the drives}}$$

$$\frac{\text{speed of the first drive}}{\text{speed of the last driven or follower}}$$

IES-73. In the compound gear train shown in the above figure, gears A and C have equal numbers of teeth and gears B and D have equal numbers of teeth. When A rotates at 800 rpm, D rotates at 200 rpm. The rotational speed of compound gears BC would then be



(a) 300 rpm
(b) 400rpm
(c) 500 rpm
(d) 600rpm

[IES 2007]

IES-73Ans. (b) From the figure $r_A + r_B = r_C + r_D$ or $T_A + T_B = T_C + T_D$ and as $N_B + N_C$ it must be $T_B = T_D$ & $T_A = T_C$

Or $\frac{N_B}{N_A} = \frac{N_D}{N_C}$ or $N_C = \sqrt{N_A N_D} = \sqrt{800 \times 200} = 400$ rpm $\left[\because N_B = N_c\right]$

Reverted gear train

IES-74. Consider the following statements in case of reverted gear train:[IES-2002]

1. The direction of rotation of the first and the last gear is the same.
2. The direction of rotation of the first and the last gear is opposite.
3. The first and the last gears are on the same shaft.
4. The first and the last gears are on separate but co-axial shafts.

Which of these statements is/are correct?

(a) 1 and 3 (b) 2 and 3 (c) 2 and 4 (d) 1 and 4

IES-74Ans. (d)

IES-75. A reverted gear train is one in which the output shaft and input shaft
(a) Rotate in opposite directions (b) are co-axial **[IES-1997]**
(c) Are at right angles to each other (d) are at an angle to each other

IES-75Ans. (b)

IES-76. In a reverted gear train, two gears P and Q are meshing, Q - R is a compound gear, and R and S are meshing. The modules of P and R are 4 mm and 5 mm respectively. The numbers of teeth in P, Q and R are 20, 40 and 25 respectively. The number of teeth in S is [IES-2003]

(a) 23 (b) 35 (c) 50 (d) 53

IES-76Ans. (a)

Summation of radius will be constant.

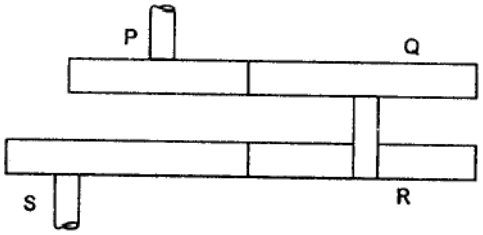
$R_P + R_Q = R_R + R_G$

or $D_P + D_Q = D_R + D_S$

or $m_1(T_P + T_Q) = m_2(T_R + T_S)$

or $4(20 + 40) = 5(25 + T_S)$

or $T_S = 23$



IES-77. Two shafts A and B, in the same straight line are geared together through an intermediate parallel shaft. The parameters relating to the gears and pinions are given in the table: [IES-2003]

Item	Speed	Teeth	PCD	Module
Driving wheel A	N_A	T_A	D_A	m
Driven wheel B	N_B	T_B	D_B	m
Driven wheel C on the intermediate shaft	N_C	T_C	D_C	m
Driving wheel D on the intermediate shaft, in mesh with B	N_D	T_D	D_D	m

(a) $\frac{N_A}{N_B} = \frac{T_C}{T_A} \times \frac{T_B}{T_D}$ (b) $\frac{N_A}{N_B} = \frac{T_A}{T_C} \times \frac{T_D}{T_B}$

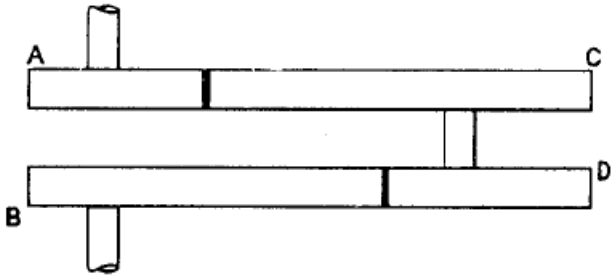
(c) $D_A + D_C = D_B + D_D$ (d) $T_A + T_C = T_B + T_D$

IES-77Ans. (b)

(i) $D_A + D_C = D_B + D_D$

(ii) $mT_A + mT_C = mT_B + mT_D$

(iii) $\frac{N_A}{N_B} = \frac{N_A}{N_C} \times \frac{N_C}{N_B} = \frac{T_C}{T_A} \times \frac{T_B}{N_D}$



IES-78. A gear having 100 teeth is fixed and another gear having 25 teeth revolves around it, centre lines of both the gears being jointed by an arm. How many revolutions will be made by the gear of 25 teeth for one revolution of arm? [IES-2009]

(a) 3 (b) 4 (c) 5 (d) 6

IES-78Ans. (c)

Arm	N_A	N_B
0	+1	$\frac{-100}{25}$

Multiplying through out by x

0	+x	$\frac{-100}{25}$x
y	y + x	y – 4x

Given that $y + x = 0 \therefore x = -y = -1$

$(\because y = 1)$

$\therefore \quad N_B = y - 4x = 5$

Epicyclic gear train

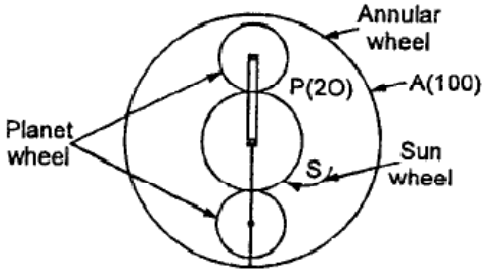
IES-79. If the annular wheel of an epicyclic gear train has 100 teeth and the planet wheel has 20 teeth, the number of teeth on the sun wheel is [IES-2003]
(a) 80 (b) 60 (c) 40 (d) 20

IES-79Ans. (b) From geometry

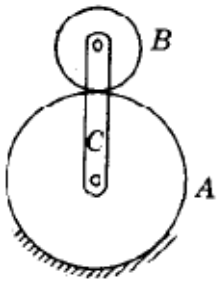
$$2d_p + d_s = d_A$$

$$or\ 2T_p + T_s = T_A$$

$$or\ T_s = T_A - 2T_p = 100 - 2\times 20 = 60$$



IES-80. In the epicyclic gear train shown in the given figure, A is fixed. A has 100 teeth and B has 20 teeth. If the arm C makes three revolutions, the number of revolutions made by B will be
(a) 12
(b) 15
(c) 18
(d) 24



[IES-1997]

IES-80Ans. (c) For 1 revolution of C,

$$N_B = 1 + \frac{T_A}{T_B} = 1 + \frac{100}{20} = 6 \quad \therefore \text{for 3 revolution, } N_D = 6\times 3 = 18$$

IES-81. An epicyclic gear train has 3 shafts A, B and C, A is an input shaft running at 100 rpm clockwise. B is an output shaft running at 250 rpm clockwise. Torque on A is 50 kNm (clockwise). C is a fixed shaft. The torque to fix C
(a) Is 20 kNm anticlockwise **[IES-2002]**
(b) is 30 kNm anticlockwise
(c) Is 30 kNm clockwise
(d) Cannot be determined as the data is insufficient

IES-81Ans. (b)

Now $\omega_1 M_1 - \omega_2 M_2 = 0$

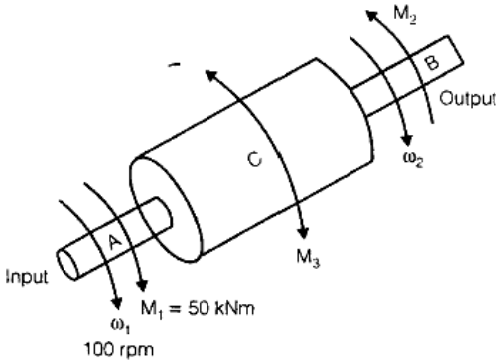
$\therefore \quad M_2 = \dfrac{100 \times 50}{250} = 20$ KNm(anticlockwise)

and $\overrightarrow{M_1} + \overrightarrow{M_2} + \overrightarrow{M_3} = 0$

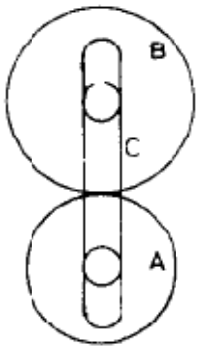
$50 - 20 + \overrightarrow{M_3} = 0$

$\therefore \quad \overrightarrow{M_3} = -30$kNm(clockwise)

$= 30$kNm(anticlockwise)



IES-82. A single epicyclic gear train is shown in the given figure. Wheel A is stationary. If the number of teeth on A and Bare 120 and 45 respectively, then when B rotates about its own axis at 100 rpm, the speed of C would be



(a) 20 rpm (b) $27\dfrac{3}{11}$ rpm

(c) $19\dfrac{7}{11}$ rpm (d) 100 rpm

[IES-1994]

IES-82Ans. (c)

Terminology of Helical Gears

IES-83. If α = helix angle, and p_c = circular pitch; then which one of the following correctly expresses the axial pitch of a helical gear? [IES 2007]

(a) $p_c \cos\alpha$ (b) $\dfrac{p_c}{\cos\alpha}$ (c) $\dfrac{p_c}{\tan\alpha}$ (d) $p_c \sin\alpha$

IES-83Ans. (c)

IES-84A helical gear has the active face width equal to b, pitch p and helix angle α. What should be the minimum value of b in order that contact IS maintained across the entire active face of the gear? [IES-2004]

(a) $p\cos\alpha$ (b) $p\sec\alpha$ (c) $p\tan\alpha$ (d) $p\cot\alpha$

IES-84Ans. (d) $b \geq \dfrac{P}{\tan\alpha}$

IES-85. **Assertion (A):** Helical gears are used for transmitting motion and power between intersecting shafts, whereas straight bevel gears arc used for transmitting motion and power between two shafts intersecting each other at 90^{o}. **[IES-2000]**
Reason (R): In helical gears teeth are inclined to axis of the shaft and arc in the form or a helix.
Where as in bevel gears, teeth arc tapered both in thickness and height form one end to the other.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-85Ans. (d)

IES-86. **Assertion (A):** Shafts supporting helical gears must have only deep groove ball-bearings. **[IES-1999]**
Reason (R): Helical gears produce axial thrusts.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-86Ans. (a)

IES-87. **Assertion (A):** Crossed helical gears for skew shafts are not used to transmit heavy loads. **[IES-1995]**
Reason (R) The gears have a point contact, and hence are not considered strong.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-87Ans. (b)

Bevel Gears

IES-88. **In a differential mechanism, two equal sized bevel wheels A and B are keyed to the two halves of the rear axle of a motor car. The car follows a curved path. Which one of the following statements is correct? [IES-2004]**
The wheels A and B will revolve at different speeds and the casing will revolve at a speed which is equal to the
(a) Difference of speeds of A and B
(b) Arithmetic mean of speeds of A and B
(c) Geometric mean of speeds of A and B
(d) Harmonic mean of speeds of A and B

IES-88Ans. (d)

Worm Gears

IES-89. **Assertion (A):** Tapered roller bearings must be used in heavy duty worm gear speed reducers. **[IES-2005]**
Reason (R): Tapered roller bearings are suitable for large radial as well as axial loads.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false

(d) A is false but R is true

IES-89Ans. (a)

IES-90. Consider the following statements in respect of worm gears: [IES-2005]

1. They are used for very high speed reductions.
2. The velocity ratio does not depend on the helix angle of the worm.
3. The axes of worm and gear are generally perpendicular and non-intersecting.

Which of the statements given above are correct?

(a) 1 and 2 (b) 1 and 3 (c) 2 and 3 (d) 1, 2 and 3

IES-90Ans. (d)

IES-91. For a speed ratio of 100 smallest gear box is obtained by using which of the following? [IES-2008]

(a) A pair of spur gears
(b) A pair of bevel and a pair of spur gears in compound gear train
(c) A pair of helical and a pair of spur gears in compound gear train
(d) A pair of helical and a pair of worm gears in compound gear train

IES-91.Ans. (d)

IES-92. Consider the following statements regarding improvement of efficiency of worm gear drive: [IES-2004]

1. Efficiency can be improved by increasing the spiral angle of worm thread to 45° or more
2. Efficiency can be improved by adopting proper lubrication
3. Efficiency can be improved by adopting worm diameter as small as practicable to reduce sliding between worm-threads and wheel teeth
4. Efficiency can be improved by adopting convex tooth profile both for worm and wheel

Which of the statements given above are correct?

(a) 1, 2 and 3 (b) 1, 2 and 4 (c) 2, 3 and 4 (d) 1, 3 and 4

IES-92Ans. (a)

$$\text{Gear } \eta_{\text{wormgear}} = \frac{\tan\lambda}{\tan(\phi_v + \lambda)}$$

$$\tan\phi_v = \pi_v$$

$$\tan\lambda = \frac{z_w.m}{d_W}$$

The face of worm gear is made concave to envelope the worm.

IES-93. The lead angle of a worm is 22.5 deg. Its helix angle will be [IES-1994]

(a) 22. 5 deg. (b) 45 deg. (c) 67.5 deg. (d) 90°C.

IES-93Ans. (c) α = Pressure angle ≅ lead angle; α + β = 90°; β = helix angle = 90° - 22.5° = 67.5°

Previous 20-Years IAS Questions

Spur gear

IAS-1. Match List I (Terms) with List II (Definition) and select the correct answer using the codes given below the lists: [IAS-2001]

List I	List II
A. Module	1. Radial distance of a tooth from the pitch circle to the top of the tooth

B. Addendum — 2. Radial distance of a tooth from the pitch circle to the bottom of the tooth

C. Circular pitch — 3. Distance on the circumference of the pitch circle from a point of one tooth to the corresponding point on the next tooth

4. Ratio of a pitch circle diameter in mm to the number of teeth

Codes:	A	B	C		A	B	C
(a)	4	1	3	(b)	4	2	3
(c)	3	1	2	(d)	3	2	4

IAS-1Ans. (a)

IAS-2 Consider the following specifications of gears A, B, C and D: [IAS-2001]

Gears	A	B	C	D
Number of teeth	20	60	20	60
Pressure angle	$14\frac{1}{2}^o$	$14\frac{1}{2}^o$	20^o	$14\frac{1}{2}^o$
Module	1	3	3	1
Material	Steel	Brass	Brass	Steel

Which of these gears form the pair of spur gears to achieve a gear ratio of 3?

(a) A and B (b) A and D (c) B and C (d) C and D

IAS-2Ans. (b)

For a gear pair i) module must be same

(ii) Pressure angle must be same.

IAS-3. If the number of teeth on the wheel rotating at 300 r.p.m. is 90, then the number of teeth on the mating pinion rotating at 1500 r.p. m. is[IAS-2000]

(a) 15 (b) 18 (c) 20 (d) 60

IAS-3Ans. (b)

Peripheral velocity (πDN) = constant. $\pi D_1N_1 = \pi D_2N_2$ and $D = mT$

$$or\ \pi mT_1N_1 = \pi mT_1N_1\ or\ T_2 = T_1 \times \frac{N_1}{N_2} = 90 \times \frac{300}{1500} = 18$$

Or you may say speed ratio, $\frac{N_1}{N_2} = \frac{T_2}{T_1}$

IAS-4. A rack is a gear of [IAS-1998]

(a) Infinite diameter (b) infinite module

(c) zero pressure angle (d) large pitch

IAS-4Ans. (a)

Classification of Gears

IAS-5. Assertion (A): While transmitting power between two parallel shafts, the noise generated by a pair of helical gears is less than that of an equivalent pair of spur gears. **[IAS-2000]**

Reason(R): A pair of helical gears has fewer teeth in contact as compared to an equivalent pair of spur gears.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is **not** the correct explanation of A

(c) A is true but R is false
(d) A is false but R is true

IAS-5Ans. (c) In spur gears, the contact between meshing teeth occurs along the entire face width of the tooth, resulting in a sudden application of the load which, in turn, results in impact conditions and generates noise.
In helical gears, the contact between meshing teeth begins with a point on the leading edge of the tooth and gradually extends along the diagonal line across the tooth. There is a gradual pick-up of load by the tooth, resulting in smooth engagement and silence operation.

Pitch point

IAS-6. An imaginary circle which by pure rolling action, gives the same motion as the actual gear, and is called [IAS-2000]
(a) Addendum circle (b) pitch circle
(c) Dedendum circle (d) base circle

IAS-6Ans. (b)

Pressure angle

IAS-7. The pressure angle of a spur gear normally varies from [IAS-2000]
(a) 14° to 20° (b) 20° to 25° (c) 30° to 36° (d) 40° to 50°

IAS-7Ans. (a)

Minimum Number of Teeth

IAS-8. Minimum number of teeth for involute rack and pinion arrangement for pressure angle of 20° is [IAS-2001]
(a) 18 (b) 20 (c) 30 (d) 34

IAS-8Ans. (a) $T_{\min} = \frac{2h_f}{\sin^2\theta} = \frac{2\times 1}{\sin^2 20^o} = 17.1 \quad as > 17 \quad \text{So} T_{\min} = 18$

Cycloidal teeth

IAS-9. The tooth profile most commonly used in gear drives for power transmission is [IAS-1996]
(a) A cycloid (b) An involute (c) An ellipse (d) A parabola

IAS-9Ans. (b) It is due to easy manufacturing.

Contact ratio

IAS-10. Which one of the following statements is correct? [IAS-2007]
(a) Increasing the addendum results in a larger value of contact ratio
(b) Decreasing the addendum results in a larger value of contact ratio
(c) Addendum has no effect on contact ratio
(d) Both addendum and base circle diameter have effect on contact ratio

IAS-10Ans. (d) contact ratio= $\frac{length\ of\ are\ of\ contant}{circular\ pitch}$

$$=\frac{\sqrt{R_{A^2}-R^2\cos^2\theta}+\sqrt{r_{A^2}-r^2\cos^2\theta}-(R+r)\sin\theta}{P_c(\cos\theta)}$$

IAS-11. The velocity of sliding of meshing gear teeth is [IAS-2002]

(a) $(\omega_1\times\omega_2)x$ (b) $\frac{\omega_1}{\omega_2}x$ (c) $(\omega_1+\omega_2)x$ (d) $\frac{(\omega_1+\omega_2)}{x}$

(Where ω_1 and ω_2 = angular velocities of meshing gears
x = distance between point of contact and the pitch point)

IAS-11Ans. (c)

Interference

IAS-12. For spur with gear ratio greater than one, the interference is most likely to occur near the [IAS-1997]

(a) Pitch point (b) point of beginning of contact
(c) Point of end of contact (d) root of the tooth

IAS-12Ans. (d)

IAS-13. How can interference in involute gears be avoided? [IAS-2007]

(a) Varying the centre distance by changing the pressure angle only
(b) Using modified involute or composite system only
(c) Increasing the addendum of small wheel and reducing it for the larger wheel only
(d) Any of the above

IAS-13Ans. (d)

IAS-14. Which one of the following statements in respect of involute profiles for gear teeth is not correct? [IAS-2003]

(a) Interference occurs in involute profiles,
(b) Involute tooth form is sensitive to change in centre distance between the base circles.
(c) Basic rack for involute profile has straight line form
(d) Pitch circle diameters of two mating involute gears are directly proportional to the base circle diameter

IAS-14Ans. (b)

IAS-15. Assertion (A): In the case of spur gears, the mating teeth execute pure rolling motion with respect to each other from the commencement of engagement to its termination. **[IAS-2003]**

Reason (R): The involute profiles of the mating teeth are conjugate profiles which obey the law of gearing.

(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IAS-15Ans. (a)

IAS-16. **Assertion (A):** Gears with involute tooth profile transmit constant velocity ratios between shafts connected by them. **[IAS-1997]**
Reason (R): For involute gears, the common normal at the point of contact between pairs of teeth always passes through the pictch point.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IAS-16Ans. (a)

Compound gear train

IAS-17. **There are six gears A, B, C, D, E, F in a compound train. The numbers of teeth in the gears are 20, 60, 30, 80, 25 and 75 respectively. The ratio of the angular speeds of the driven (F) to the driver (A) of the drive is**
(a) $\frac{1}{24}$ (b) $\frac{1}{8}$ (c) $\frac{4}{15}$ (d) 12 **[IAS-1995]**

IAS-17Ans. (a)

$$\text{The ratio of angular speeds of F to A} = \frac{T_A.T_C.T_E}{T_B.T_D.T_F} = \frac{20\times30\times25}{60\times80\times75} = \frac{1}{24}$$

Epicyclic gear train

IAS-18. **A fixed gear having 100 teeth meshes with another gear having 25 teeth, the centre lines of both the gears being joined by an arm so as to form an epicyclic gear train. The number of rotations made by the smaller gear for one rotation of the arm is** **[IAS-1995]**
(a) 3 (b) 4 (b) 5 (d) 6

IAS-18Ans. (c)

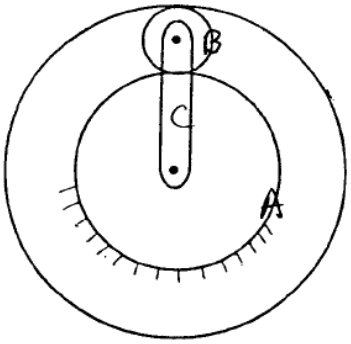
$$\text{Revolution of 25 teeth gear} = 1 + \frac{T_{100}}{T_{25}}(\text{for one rotation of arm}) = 1 + \frac{100}{25} = 5$$

IAS-19. **For an epicyclic gear train, the input torque = 100 Nm. RPM of the input gear is 1000 (clockwise), while that of the output gear is 50 RPM (anticlockwise). What is the magnitude of the holding torque for the gear train?** **[IAS-2007]**
(a) Zero (b) 500 Nm (c) 2100 Nm (d) None of the above

IAS-19Ans. (c) $T_i+T_o+T_{arm}=0$ and $T_i\omega_i + T_o\omega_o + T_{arm}\omega_{arm} = 0$

$$\text{Gives, } T_{arm}=T_i\left(\frac{\omega_i}{\omega_o}-1\right)=T_i\left(\frac{N_i}{N_o}-1\right)=100\times\left(\frac{-1000}{50}-1\right)=-2100\,Nm$$

IAS-20. **In the figure shown, the sun wheel has 48 teeth and the planet has 24 teeth. If the sun wheel is fixed, what is the angular velocity ratio between the internal wheel and arm?**



(a) 3.0

(b) 1.5

(c) 2.0

(d) 4.0

[IAS-2004]

IAS-20Ans. (a) $\frac{N_B - N_C}{N_A - N_C} = -\frac{T_A}{T_B} \quad \because N_A = 0$

$\frac{N_B - N_C}{-N_C} = -\frac{48}{24} \quad or - \frac{N_B}{N_C} + 1 = -2 \quad or \quad \frac{N_B}{N_C} = 2 + 1 = 3$

IAS-21. **100 kW power is supplied to the machine through a gear box which uses an epicyclic gear train. The power is supplied at 100 rad/s. The speed of the output shaft of the gear box is 10 rad/s in a sense opposite to the input speed. What is the holding torque on the fixed gear of the train?** **[IAS-2004]**

(a) 8 kNm (b) 9 kNm (c) 10 kNm (d) 11 kNm

IAS-21Ans. (b) $T_1+T_2+T_3=0$

$T_1W_1+T_2W_2+T_3W_3=0$

$W_3=0$

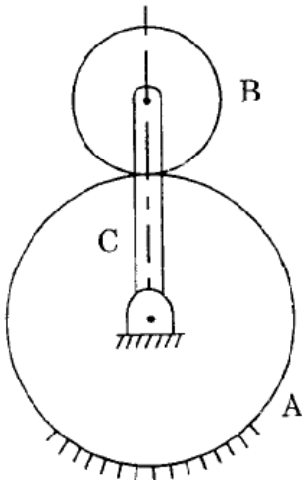
$T_1W_1=100kW, \ W_1=100rad/s$

$\because \ T_1=1$ k Nm

Or $T_2=-\frac{T_1W_1}{W_2}=\frac{-100}{(10)}=-10kNm$

$T_3=-T_2-T_1=-(-10)-1=9kNm$

IAS-22. **In the epicyclic gear train shown in the figure, T_A = 40, T_B = 20. For three revolutions of the arm, the gear B will rotate through**



(a) 6 revolutions

(b) 2.5 revolutions

(c) 3 revolutions

(d) 9 revolutions

[IAS-2003]

IAS-22Ans. (d)

Bevel Gears

IAS-23. Assertion (A): Spiral bevel gears designed to be used with an offset in their shafts are called 'hypoid gears' **[IAS-2004]**
Reason (R): The pitch surfaces of such gears are hyperboloids of revolution.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IAS-23Ans. (a)

Worm Gears

IAS-24. If reduction ratio of about 50 is required in a gear drive, then the most appropriate gearing would be [IAS-1999]
(a) spur gears (b) bevel gears
(c) Double helical gears (d) worm and worm wheel

IAS-24Ans. (d)

IAS-25. Speed reduction in a gear box is achieved using a worm and worm wheel. The worm wheel has 30 teeth and a pitch diameter of 210 mm. If the pressure angle of the worm is 20°, what is the axial pitch of the worm?
(a) 7 mm (b) 22 mm **[IAS-2004]**
(c) 14 mm (d) 63 mm

IAS-25Ans. (b) $m = \frac{210}{30} = 7$ *and* $P_x = \pi m = \frac{22}{7} \times 7 = 22mm$

Axial pitch = circular pitch of the worm wheel= πm

IAS-24. A speed reducer unit consists of a double-threaded worm of pitch = 11 mm and a worm wheel of pitch diameter = 84 mm. The ratio of the output torque to the input to rque is IAS-2002]
(a) 7·6 (b) 12 (c) 24 (d) 42

IAS-24Ans. (a) $\frac{\text{Output torque}}{\text{Input torque}} = \frac{\text{pitch diameter of worm wheel}}{\text{pitch of worm}} = \frac{84}{11} = 7.6$

IAS-25. The maximum efficiency for spiral gears in mesh is given by (Where (θ = shaft angle and ϕ, = friction angle) [IAS-1998]
(a) $\frac{1+\cos(\theta-\phi)}{1+\cos(\theta+\phi)}$ (b) $\frac{1+\cos(\theta+\phi)}{1+\cos(\theta-\phi)}$
(c) $\frac{1-\cos(\theta-\phi)}{1+\cos(\theta+\phi)}$ (d) $\frac{1-\cos(\theta+\phi)}{1+\cos(\theta-\phi)}$

IAS-Ans. (b)

IAS-26. Assertion (A): A pair of gears forms a rolling pair. **[IAS-1996]**
Reason (R): The gear drive is a positive drive.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IAS-26Ans. (d) In rolling pair one link rolls over another fixed link.

4. Design of Bearings

Objective Questions (IES, IAS, GATE)

Previous 20-Years GATE Questions

Types of Rolling Contact Bearings

GATE-1. Spherical roller bearings are normally used [GATE-1992]
(a) For increased radial load (b) for increased thrust load
(c) When there is less radial space (d) to compensate for angular misalignment

GATE-1Ans. (d) It is also true for (a) but (d) is more appropriate.

Load-life Relationship

GATE-2. The rated life of a ball bearing varies inversely as which one of the following? [GATE-1993; IES-2004]
(a) Load (b) $(load)^2$ (c) $(load)^3$ (d) $(load)^{3.33}$

GATE-2Ans. (c) $L = \left(\frac{d}{R}\right)^p$, d = dynamic load capacity

R = Equivalent bearing load

p = 3 for ball bearing

$= \frac{10}{3}$ for roller bearing.

GATE-3. The life of a ball bearing at a load of 10 kN is 8000 hours. Its life in hours, if the load is increased to 20 kN, keeping all other conditions the same, is
(a) 4000 (b) 2000 (c) 1000 (d) 500 **[GATE-2000]**

GATE-3 Ans. (c)

$$Life \propto \left(\frac{1}{P}\right)^3$$

$$\Rightarrow \quad L_2 = L_1\left(\frac{P_1}{P_2}\right)^3 = 8000\left(\frac{10}{20}\right)^3 = 1000\, hrs.$$

GATE-4. The dynamic load capacity of 6306 bearing is 22 kN. The maximum radial load it can sustain to operate at 600 rev/min, for 2000 hours is [GATE-1997]
(a) 4.16 kN (b) 3.60 kN (c) 6.2S kN (d) 5.29 kN

GATE-4 Ans. (d)

Number of revolutions in life = $2000 \times 60 \times 600$
$= 72 \times 10^5$ revolutions

L = 72

Maximum radial load = $\frac{2\ 2}{\sqrt[3]{L}} = \frac{2\ 2}{\sqrt[3]{7\ 2}} = 5.29\ kN$

GATE-5. The basic load rating of a ball bearing is [GATE-1998]

(a) The maximum static radial load that can be applied without causing any plastic deformation of bearing components.

(b) The radial load at which 90% of the group of apparently identical bearings run for one million revolutions before the first evidence of failure.

(c) The maximum radial load that can be applied during operation without any plastic deformation of bearing components.

(d) A combination of radial and axial loads that can be applied without any plastic deformation.

GATE-5 Ans. (b)

Basic Modes of Lubrication

GATE-6. Which one of the following is a criterion in the design of hydrodynamic journal bearings? [GATE-2005]

(a) Sommerfeld number (b) rating life

(c) Specific dynamic capacity (d) Rotation factor

GATE-6 Ans. (a) Sommerfeld Number, also Known as bearing Characteristic Number,

$$s = \frac{z_n}{P}.\left(\frac{D}{C_d}\right)^2$$

GATE-7. A natural feed journal bearing of diameter 50 mm and length 50 mm operating at 20 revolution/second carries a load of 2.0 KN. The lubricant used has a viscosity of 20 mPas. The radial clearance is 50 µm. The Sommerfeld number for the bearing is [GATE-2007]

(a) 0.062 (b) 0.125 (c) 0.250 (d) 0.785

GATE-7Ans. (b) Sommerfield number S = $\left(\frac{r}{c}\right)^2 \times \frac{\mu N}{P}$

Where, r is radius of journal

μ is viscosity of lubricant

N is number of revolution per second

P is bearing pressure on projected Area

C is radial clearance

Therefore, $P = \frac{P}{d \times l} = \frac{2000}{50 \times 50} = 0.8N/mm^2$

$$S = \left(\frac{25}{50 \times 10^{-3}}\right)^2 \times \frac{20 \times 20 \times 10^{-3}}{0.8 \times 10^6}$$

$$= 0.125$$

GATE-8. To restore stable operating condition in a hydrodynamic journal bearing, when it encounters higher magnitude loads, [GATE-1997]

(a) Oil viscosity is to be decreased (b) oil viscosity is to be increased

(c) Oil viscosity index is to be increased (d) oil viscosity index is to be decreased

GATE-8Ans. (b)

GATE-9. List l List II [GATE-1997]

(A) Automobile wheel mounting on axle 1. Magneto bearing

(B) High speed grinding spindle 2. Angular contact bearing

(C) I.C. Engine connecting rod **3. Taper roller bearing**
(D) Leaf spring eye mounting **4. Hydrodynamic journal bearing**
5. Sintered metal bearing
6. Teflon/Nylon bush.

GATE-9Ans. (A) -3, **(B)** -1, **(C)**-4, (0)-6

GATE-10.In thick film hydrodynamic journal bearings, the coefficient of friction
(a) Increases with increases in load (b) is independent of load **[GATE-1996]**
(c) Decreases with increase in load (d) may increase or decrease with increase in load

GATE-10Ans. (c)

Hydrostatic Step Bearing 464

GATE-11.Starting friction is low in **[GATE-1992]**
(a) Hydrostatic lubrication (b) Hydrodynamic lubrication
(c) Mixed (or semi-fluid) lubrication (d) Boundary lubrication

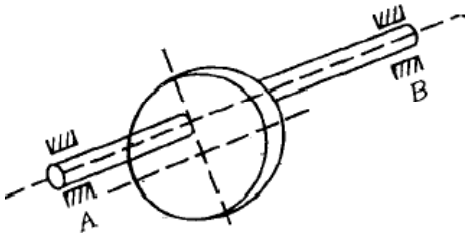
GATE-11Ans. (a)

Previous 20-Years IES Questions

IES-1. Consider the following statements about antifriction bearings: [IES-2008]
1. Their location influences the lateral critical speed of a rotor.
2. Roller bearings are antifriction bearings.
Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

IES-1Ans. (c)

IES-2. A circular disc having a mass of 30 kg is mounted asymmetrically between two bearings A and B as shown above in the figure. It is used as an eccentric cam with an eccentricity of 0.01 m. If the shaking force on each of the bearings is not to exceed 1500 N, the speed of rotation of the cam should not exceed



(a) 10 rad/s (b) 100 rad/s
(c) 70.7 rad/s (d) 140 rad/s

[IES-2003]

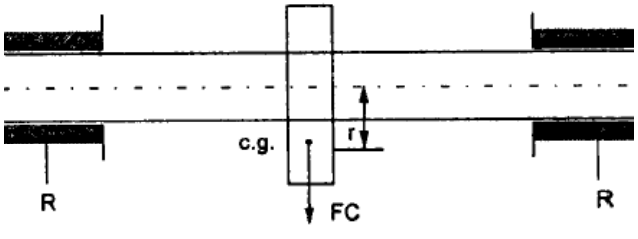
IES-2 Ans. (b)

R_{max} = 1500 N

F_c = 2 x R = 2 x 1500 N

$m\omega^2 r = 2 \times 1500$

or $\omega = \left(\frac{2\times1500}{30\times0.01}\right)^{1/2}$ = 100 rad / see



Types of Rolling Contact Bearings

IES-3. In three ball bearing identified as SKF 2015, 3115 and 4215 **[IES-2008]**

(a) Bore is common but width is increasing
(b) Outer diameter is common but bore is increasing
(c) Width is common but outer diameter is decreasing
(d) Bore is common but outer diameter is decreasing

IES-3Ans. (a) According to ISO plan for dimension series bearings are provided with two digit numbers. The first number indicates the width series 8, 0, 1, 2, 3, 4, 5 and 6 in order of increasing width. The second number indicate diameter series 7, 8, 9, 0, 1, 2, 3, and 4 in order of ascending outer diameter of bearing. Thus bearing number SKF 2015, 3115 and 4215 shows bearings belonging to different series with 75 mm bore diameter but width is increasing.

SKF 2015, 3115 and 4215 shows width is increasing ascending outer diameter of bearing same bore diameter 75 mm. (i.e. 15 × 5)

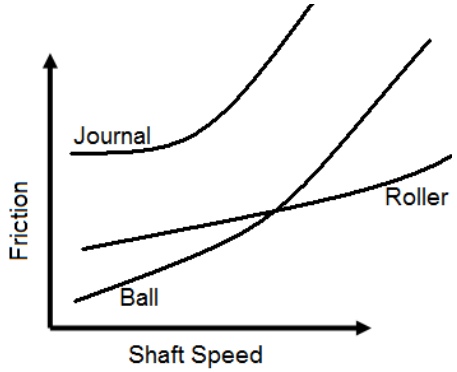
IES-4. Average values of effective coefficients of friction for bearings are described below: **[IES 2007]**

1. Spherical ball bearing - f_1 **2. Cylindrical roller bearing -f_2**
3. Taper roller bearing - f_3 **4. Stable (thick film) Sliding contact bearing - f_4**

Which one of the following sequences is correct?

(a) $f_1 < f_2 < f_3 < f_4$ (b) $f_1 < f_2 < f_4 < f_3$
(c) $f_2 < f_1 < f_3 < f_4$ (d) $f_1 < f_4 < f_2 < f_3$

IES-4Ans. (a)



IES-5. The rating life of a group of apparently identical ball bearings is defined as the number of revolutions or exceeded before the first evidence of fatigue crack by: **[IES-2005]**

(a) 100% of the bearings of the group (b) 95% of the bearings of the group
(c) 90% of the bearings of the group (d) 66.66% of the bearings of the group

IES-5Ans. (c)

IES-6. Match List I (Type of Bearings) with List II (Type of Load) and select the correct answer using the code given below the Lists: **[IES-2005]**

List I	List II
A Deep groove bearing	1. Radial load
B. Tapered roller bearing	2. Radial and axial load
C. Self aligning being	3. Mainly radial load with shaft misalignment
D. Thrust bearing	4. Mainly axial load

	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	3	4	1	2

(c) 1 4 3 2 (d) 3 2 1 4

IES-6Ans. (a)

IES-7. Which one of the following statements is correct? [IES-2004]
Antifriction bearings are
(a) Sleeve bearings (b) gas lubricated bearings
(c) Ball and roller bearings (d) journal bearings

IES-7Ans. (c)

IES-8. The rolling element bearings are [IES-2003]
(a) Hydrostatic bearings (b) Squeeze film bearings
(c) Antifriction bearings (d) Grease lubrication bearings

IES-8Ans. (c)

IES-9. A ball-bearing is characterized by basic static capacity = 11000 N and dynamic capacity = 18000 N. This bearing is subjected to equivalent static load = 5500 N. The bearing loading ratio and life in million revolutions respectively are [IES-2001]
(a) 3.27 and 52.0 (b) 3.27 and 35.0 (c) 2.00 and 10.1 (c) 1.60 and 4.1

IES-9Ans. (b) $Loading\ ratio = \frac{C}{P} = \frac{18000}{5500} = 3.27$

Life (million revolutions)

$= \left(\frac{C}{P}\right)^3 = \left(\frac{18000}{5500}\right)^3 = 35$

IES-10. On what does the basic static capacity of a ball bearing depends?
(a) Directly proportional to number of balls in a row and diameter of ball **[IES-2009]**
(b) Directly proportional to square of ball diameter and inverse of number of rows of balls
(c) Directly proportional to number of balls in a row and square of diameter of ball
(d) Inversely proportional to square of diameter of ball and directly proportional to number of balls in a row

IES-10Ans. (c)

IES-11. Ball bearings are provided with a cage [IES-1992]
(a) To reduce friction
(b) To maintain the balls at a fixed distance apart
(c) To prevent the lubricant from flowing out
(d) To facilitate slipping of balls

IES-11Ans. (b)

IES-12. In a single row deep groove ball-bearing, cages are needed to [IES-1999]
(a) Separate the two races
(b) Separate the balls from the inner race
(c) Separate the outer race from the balls
(d) Ensure that the balls do not cluster at one point and maintain proper relative angular positions.

IES-12Ans. (d)

IES-13. Which one of the following statements is NOT true of rolling contact bearing? [IES-1997]
(a) The bearing characteristic number is given by ZN/p where Z is the absolute viscosity of the lubricant, N is the shaft speed and p is the bearing pressure.

(b) Inner race of a radial ball bearing has an interference fit with the shaft and rotates along with it
(c) Outer race of the bearing has an interference fit with bearing housing and does not rotate
(d) In some cases, the inner race is stationary and outer race rotates

IES-13Ans. (d)

IES-14. Assertion (A): It is desirable to increase the length of arc over which the oil film has to be maintained in a journal bearing. **[IES-1996]**
Reason (R): The oil pressure becomes negative in the divergent part and the partial vacuum created will cause air to leak in from the ends of bearing.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-14Ans. (a)

IES-15. Consider the following statements about anti-friction bearings: [IES-1994]
1. They have low starting and low running friction at moderate speeds.
2. They have high resistance to shock loading.
3. They can carry both radial and thrust loads.
4. Their initial cost is high.
5. They can accommodate some amount of misalignments of shaft.
Of these statements
(a) 1, 2, 3 and 4 are correct (b) 1,3 and 4 are correct
(c) 1, 4 and 5 are correct (d) 1, 2, 3 and 5 are correct.

IES-15Ans. (a) Self aligning bearing can accommodate some amount of misalignments of shaft.

IES-16. Removal of metal particles from the raceway of a rolling contact bearing is a kind of failure of bearing known as [IES-1995]
(a) Pitting (b) wearing (c) spalling (d) scuffing

IES-16Ans. (a)

Load-life Relationship

IES-17. The rated life of a ball bearing varies inversely as which one of the following? [GATE-1993; IES-2004]
(a) Load (b) $(load)^2$ (c) $(load)^3$ (d) $(load)^{3.33}$

IES-17 Ans. (c) $L = \left(\frac{d}{R}\right)^P$, d = dynamic load capacity

R = Equivalent bearing load

p = 3 for ball bearing

$= \frac{10}{3}$ for roller bearing.

IES-18. If the load on a ball bearing is halved, its life: [IES-2005]
(a) Remains unchanged (b) Increases two times
(c) Increases four times (d) Increases eight times

IES-18Ans. (d) $L = \left(\frac{d}{R}\right)^3$ d is dynamic load carrying capacity. R is actual load applied if R halved L will increased by $2^3 = 8$ times

Selection of Taper Roller Bearings

IES-19. **Assertion (A):** Tapered roller bearings are sensitive to the tightening between inner and outer races. **[IES-2002]**
Reason (R): Tapered roller bearings are always provided with adjusting nut for tightening.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-19Ans. (b)

IES-20. **Which bearing is preferred for oscillating conditions?** **[IES-1992]**
(a) Double row roller bearing
(b) Angular contact single row ball bearing
(c) Taper roller bearing
(d) Needle roller bearing

IES-20Ans. (d)

IES-21. **Match List-I (Bearings) with List-II (Applications) and select the correct answer using the codes given below the lists:** **[IES-2001]**

List I	**List II**
A. Cylindrical roller	**1. Radial loads**
B. Ball-bearing	**2. Machine needs frequent dismantling and assembling**
C. Taper rolling bearing	**3. Radial loads with lesser thrust**
D. Angular contact ball-bearing	**4. Shock loads**
	5. Axial expansion of shaft due to rise in temperature

	A	B	C	D		A	B	C	D
(a)	4	3	1	5	(b)	1	3	2	5
(c)	4	1	2	3	(d)	5	4	1	3

IES-21Ans. (c)

IES-22. **Match List-I with List-II and select the correct answer using the codes given below the lists:** **[IES-1998]**

List I	**List II**
A. End thrust	**1. Plain bearing**
B. No cage	**2. Ball bearing**
C. More accurate centering	**3. Needle bearing**
D. Can be overloaded	**4. Tapered roller bearing**

Code:	A	B	C	D		A	B	C	D
(a)	3	4	2	1	(b)	4	3	1	2
(c)	3	4	1	2	(d)	4	3	2	1

IES-22 Ans. (d)

IES-23. **Match List-I with List-II and select the correct answer using the codes given below the Lists:** **[IES-1997]**

List-I (Bearing)	**List-II (Purpose)**
A. Ball bearing	**1. Heavy loads with oscillatory motion**
B. Tapered Roller bearings	**2. Light loads**
C. Spherical Roller bearings	**3. Carrying both radial and thrust loads**
D. Needle Roller bearings	**4. Self-aligning property**

Codes:	A	B	C	D		A	B	C	D
(a)	4	1	3	2	(b)	2	1	4	3
(c)	2	3	1	4	(d)	2	3	4	1

IES-23 Ans. (d)

IES-24. Tapered roller bearings can take **[IES-1996]**
(a) Radial load only
(b) Axial load only
(c) Both radial and axial loads and the ratio of these being less than unity.
(d) Both radial and axial loads and the ratio of these being greater than unity.

IES-24Ans. (d)

IES-25. In a collar thrust bearing, the number of collars has been doubled while maintaining coefficient of friction and axial thrust same. It will result in
(a) Same friction torque and same bearing pressure **[IES-2002]**
(b) Double friction torque and half bearing pressure
(c) Double friction torque and same bearing pressure
(d) Same friction torque and half bearing pressure

IES-25 Ans. (d)

Sliding Contact Bearings

IES-26. Which of the following are included in the finishing operations for porous bearing? **[IES-2005]**
1. Infiltration 2. Sizing 3. Heat treatment 4.Coining
Select the correct answer using the code given below:
(a) 1 and 2 (b) 2 and 3 (c) 2 and 4 (d) 1 and 4

IES-26Ans. (a)

Basic Modes of Lubrication

IES-27. In sliding contact bearings, a positive pressure can be built up and a load supported by a fluid only by the use of a: **[IES-2005]**
(a) Diverging film (b) Converging-diverging film
(c) Converging film (d) Flat film

IES-27Ans. (c)

IES-28. Which one of the following is correct? **[IES-2008]**
A hydrodynamic slider bearing develops load bearing capacity mainly because of
(a) Slider velocity (b) wedge shaped oil film
(c) Oil compressibility (d) oil viscosity

IES-28Ans. (b) A hydrodynamic slider bearing develops load bearing capacity mainly because of wedge shaped oil film.

IES-29. Assertion (A): In steady rotating condition the journal inside a hydrodynamic journal bearing remains floating on the oil film. **[IES-2008]**
Reason (R): The hydrodynamic pressure developed in steady rotating conditions in journal bearings balances the load on the journal.
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-29Ans. (a) The film pressure created by the moving surface itself pulling the lubricant into a wedge shaped zone at a velocity sufficiently high to create the necessary pressure required to separate the surface against the load on the bearings.
Hydrodynamic lubrication is also called as full film lubrication or fluid lubrication.
So Assertion and Reason both are correct and A is the correct explanation of R.

IES-30. Increase in values of which of the following results in an increase of the coefficient of friction in a hydrodynamic bearing? [IES 2007]
1. Viscosity of the oil. 2. Clearance between shaft and bearing.
3. Shaft speed.
Select the correct answer using the code given below:
(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

IES-30Ans. (b) 2 is false Petroff's law says

$$\text{Co efficient of friction (f)} = 2\pi \frac{\mu N_S}{P} \times \left(\frac{r}{c}\right)$$

f ↑ if (i) $\mu \uparrow$; (ii) c↓ ; (iii) $N_s \uparrow$

IES-31. A journal bearing with hydrodynamic lubrication is running steadily with a certain amount of minimum film thickness. When the load and speed are doubled, how does the minimum film thickness vary? [IES-2008]
(a) Remains unchanged
(b) Gets doubled
(c) Gets reduced to one-fourth of original value
(d) Gets reduced to half of original value

IES-32Ans. (a) When the load and speed is doubled, the minimum film thickness remains unchanged. Since, $S = \left(\frac{\mu N}{p}\right)\left(\frac{r}{c}\right)^2$

Since S remains the same even after doubling the speed as well as load and film Thickness depends on the Sommerfeld number.

IES-33. What is the main advantage of hydrodynamic bearing over roller bearing?
(a) Easy to assemble **[IES-2005]**
(b) Relatively low price
(c) Superior load carrying capacity at higher speeds
(d) Less frictional resistance

IES-33Ans. (c)

IES-34. Consider tile following statements: [IES-1993; 2002; 2006]
Radius of friction circle for a journal bearing depends upon
1. Coefficient of friction
2. Radius of the journal
3. Angular speed of rotation of the shaft
Which of the statements given above are correct?
(a) 1,2 and 3 (b) Only 1 and 2 (c) Only 2 and 3 (d) Only 1 and 3

IES-34Ans. (b) radius of friction circle = $f \times r$

IES-35. In a journal bearings, the radius of the friction circle increases with the increase in [IES-1997]
(a) Load (b) Radius of the journal
(c) Speed of the journal (d) Viscosity of the lubricant

IES-35Ans. (b)

IES-36. Consider the following statements: [IES 2007]
For a journal rotating in a bearing under film lubrication conditions, the frictional resistance is
1. Proportional to the area of contact
2. Proportional to the viscosity of lubricant
3. Proportional to the speed of rotation

4. Independent of the pressure

Which of the statements given above are correct?

(a) 1, 2, 3 and 4 (b) 1 and 4 only

(c) 2, 3 and 4 only (d) 2 and 3 only

IES-36 Ans. (a) Viscous resistance (F) = T × Area = $\frac{\mu\pi DN}{60t}\times\pi DL=\frac{\mu\pi^2D^2NL}{60t}$

IES-37. The bearing characteristic number in a hydrodynamic bearing depends on **[IES-1996]**

(a) Length, width and load (b) length, width and speed.

(c) Viscosity, speed and load (d) viscosity, speed and bearing pressure.

IES-37Ans. (d)

IES-38. It is seen from the curve that there is a minimum value of the coefficient of friction (μ) for a particular value of the Bearing Characteristic Number denoted by α. What is this value of the Bearing Characteristic Number called? **[IES-2004]**

(a) McKee Number (b) Reynolds Number

(c) Bearing Modulus (d) Somerfield Number

IES-38Ans. (c)

IES-39. Assertion (A): In equilibrium position, the journal inside a journal bearing remains floating on the oil film. **[IES-1995]**

Reason (R): In a journal bearing, the load on the bearing is perpendicular to the axis of the journal.

(a) Both A and R are individually true and R is the correct explanation of A

(b) Both A and R are individually true but R is **not** the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

IES-39Ans. (b) Both A and R are true but R is not correct explanation for A.

IES-40.A full journal bearing having clearance to radius ratio of 1/100, using a lubricant with $\mu=28\times10^{-3}$ Pa s **supports the shaft journal running at *N* = 2400 r.p.m. If bearing pressure is 1.4 MPa, the Somerfield number is** **[IES-2001]**

(a) 8×10^{-3} (b) 8×10^{-5} (c) 0.48 (d) 0.48×10

IES-40Ans. (a) $S=\frac{\mu N_s}{p}\left(\frac{r}{c}\right)^2$

IES-41. A sliding contact bearing is operating under stable condition. The pressure developed in oil film is p when the journal rotates at N r.p.m. The dynamic viscosity of lubricant is μ and effective coefficient of friction between bearing and journal of diameter D is f. Which one of the following statements is correct for the bearing? **[IES-2001]**

(a) f is directly proportional to μ and p

(b) f is directly proportional to μ and N

(c) f is inversely proportional to p and f)

(d) f is directly proportional to μ and inversely proportional to N

IES-41Ans. (b) Petroff's law $f=2\pi^2\frac{\mu n_s}{P}\left(\frac{r}{c}\right)+k\rightarrow0.002$

IES-42. Which one of the following sets of parameters should be monitored for determining safe operation of journal bearing? **[IES-2000]**

(a) Oil pressure, bearing metal temperature and bearing vibration

(b) Bearing vibration, oil pressure and speed of shaft

(c) Bearing metal temperature and oil pressure
(d) Oil pressure and bearing vibration

IES-42Ans. (a)

IES-43. Consider the following pairs of types of bearings and applications:
1. Partial Journal bearing..... Rail wagon axles [IES-2000]
2. Full journal bearing .....Diesel engine crank-shaft
3. Radial bearing .....Combined radial and axial loads
Which of these pairs is/are correctly matched?
(a) 1 alone (b) 1 and 2 (c) 2 and 3 (d) 1, 2 and 3

IES-43Ans. (b)

IES-44. Match List I with List II and select the correct answer using the code given below the lists: [IES-1995]

List I (Requirement)	**List II (Type)**
A. High temperature service	**1. Teflon bearing.**
B. High load	**2. Carbon bearing**
C. No lubrication	**3. Hydrodynamic bearing**
D. Bushings	**4. Sleeve bearing**

Codes:	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	4	1	2	3
(c)	2	1	3	4	(d)	2	3	1	4

IES-44Ans. (d)

IES-45. Assertion (A): In anti-friction bearings, the frictional resistance is very low as the shaft held by it remains in floating condition by the hydrodynamic pressure developed by the lubricant. **[IES-2006]**
Reason (R): In hydrodynamic journal bearings, hydrodynamic pressure is developed because of flow of lubricant in a converging -diverging channel
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-45Ans. (d)

IES-46. Satisfactory hydrodynamic film in a journal bearing is formed when
(a) Journal speed is low, unit pressure on the bearing is high and viscosity of lubricant used is low **[IES-2006]**
(b) Journal speed is low, unit pressure on the bearing is low and viscosity of lubricant used is low
(c) Journal speed is high, unit pressure on the bearing is high and viscosity of lubricant used is high
(d) Appropriate combination of journal speed, unit pressure on bearing and lubricant viscosity exists resulting in low coefficient of friction

IES-46Ans. (c)

IES-47. In an oil-lubricated journal bearing, coefficient of friction between the journal and the bearing. [IES-1995]
(a) Remains constant at all speeds.
(b) is minimum at zero speed and increases monotonically with increase in speed.
(c) is maximum at zero speed and decreases monotonically with increase in speed.
(d) becomes minimum at an optimum speed and then increases with further increase in speed.

IES-47Ans. (d)

IES-48. Match List I with List II and select the correct answer: [IES-2002]

List I (Bearings)	List II (Load type)
A. Hydrodynamic Journal bearing	1. High radial and thrust load combined
B. Rectangular Hydrostatic bearing	2. Radial load only
C. Taper Roller bearing	3. Thrust load only
D. Angular contact ball bearing	4. Medium to low radial and thrust combined

	A	B	C	D
(a)	2	3	1	4
(b)	4	1	3	2
(c)	2	1	3	4
(d)	4	3	1	2

IES-48 Ans. (a)

IES-49. Assertion (A): Oil as a cutting fluid result in a lower coefficient of friction.
Reason (R): Oil forms a thin liquid film between the tool face and chip, and it provides 'hydrodynamic lubrication'. **[IES-2000]**
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-49Ans. (c) Oil forms a thin liquid film between the tool face and chip, and it provides 'boundary lubrication

IES-50. Which one of the following pair is correctly matched? [IES-2000]
(a) Beauchamp tower ……First experiments on journal bearings
(b) Osborne Reynolds ……Antifriction bearings
(c) Somerfield number……Pivot and Collar bearings
(d) Ball bearings……Hydrodynamic lubrication

IES-50Ans. (a)

IES-51. Match List-I (Type of Anti-friction bearing) with List-II (Specific Use) and select the correct answer using the code given below the Lists: [IES-2006]

List-I	List -II
A. Self-aligning ball bearing	1. For pure axial load
B. Taper roller bearing	2. For hinged condition
C. Deep groove ball bearing	3. For pure radial load
D. Thrust ball bearing	4. For axial and radial load

	A	B	C	D		A	B	C	D
(a)	2	1	3	4	(b)	3	4	2	1
(c)	2	4	3	1	(d)	3	1	2	4

IES-51Ans. (c)

IES-52. Which one of the following types of bearings is employed in shafts of gearboxes of automobiles? [IES-1999]
(a) Hydrodynamic journal bearings (b) Multi-lobed journal bearings
(c) Antifriction bearings (d) Hybrid journal bearings

IES-52Ans. (c)

IES-53. Assertion (A): In hydrodynamic journal bearings, the rotating journal is held in floating condition by the hydrodynamic pressure developed in the lubricant.
Reason (R): Lubricant flows in a converging-diverging channel. **[IES-1994]**
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-53.Ans. (a) Both A and R are true and R provides correct explanation for A

Hydrostatic Step Bearing 464

IES-54. **Assertion (A):** Hydrostatic lubrication is more advantageous when compared to hydrodynamic lubrication during starting and stopping the journal in its bearing.
Reason (R): In hydrodynamic lubrication, the fluid film pressure is generated by the rotation of the journal. **[IES-1998]**
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES-54Ans. (b)

Previous 20-Years IAS Questions

Types of Rolling Contact Bearings

IAS-1. **Deep groove ball bearings are used for** **[IAS-1995]**
(a) Heavy thrust load only
(b) Small angular displacement of shafts
(c) Radial load at high speed
(d) Combined thrust and radial loads at high speed.

IAS-1Ans. (d) Deep groove ball bearings are primarily designed to support radial loads at high speeds. However, this type of construction permits the bearing also to support relatively high thrust loads in either direction.

Load-life Relationship

IAS-2. **If k = 3 for ball bearings and k = 3.33 for roller bearings, which one of the following correctly states the load (P) - Life (L) relationship for rolling contact bearings?** **[IAS-2004]**

(a) $\frac{L_1}{L_2}=\left(\frac{P_1}{P_2}\right)^k$ (b) $\frac{L_2}{L_1}=\left(\frac{P_1}{P_2}\right)^{\frac{1}{(k-1)}}$

(c) $\frac{L_2}{L_1}=\left(\frac{P_1}{P_2}\right)^k$ (d) $\frac{L_2}{L_1}=\left(\frac{P_1}{P_2}\right)^{k-1}$

IAS-2Ans. (c)

$$L=\left(\frac{d}{R}\right)^K \quad [\text{d=dynamic load carrying capacity and R= Equivalent load}]$$

$$\therefore L\,\alpha\,\frac{1}{R^K} \quad \therefore \frac{L_2}{L_1}=\left(\frac{R_1}{R_2}\right)^K$$

Basic Modes of Lubrication

IAS-3. **In a journal bearing P = average bearing pressure, Z = absolute viscosity of the lubricant, N = rotational speed of the journal. The bearing characteristic number is given by [IAS-1997]**

(a) ZN/p (b) p/ZN (c) Z/pN (d) N/Zp

IAS-3Ans. (a)

IAS-4. **Match List-I (Applications) with List-II (Choice of Bearings) and select the correct answer using the codes given below the lists: [IAS-2004]**

List – I (Applications)	**List - II (Choice of Bearings)**
A. Granite table of a coordinate measuring machine	**1. Hydrodynamic bearing**
B. Headstock spindle of a lathe	**2. Deep groove ball bearing**
C. Crank shaft of a diesel engine	**3. Hydrostatic bearing**
D. Armature of 0.5 kW induction motor	**4. Taper roller bearing**

Codes:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	1	4	3	2	(b)	3	2	1	4
(c)	1	2	3	4	(d)	3	4	1	2

IAS-4Ans. (a)

IAS-5. **In a hydrodynamic journal bearing, there is [IAS-2001]**

(a) A very thin film of lubricant between the journal and the bearing such that there is contact between the journal and the bearing

(b) A thick film of lubricant between the journal and the bearing

(c) No lubricant between the journal and the bearing

(d) A forced lubricant between the journal and the bearing

IAS-5 Ans. (b)

IAS-6. **Which one of the following is the lubricator regime during normal operation of a rolling element bearing? [IAS-2000]**

(a) Hydrodynamic lubrication (b) Hydrostatic lubrication

(c) Elasto-hydrodynamic lubrication (d) Boundary lubrication

IAS-6 Ans. (c) There is elastic deformation of the contacting surfaces as surfaces are not sufficiently rigid. Here fluid film pressure is also high.

IAS-7. **A journal bearing of diameter 25 cm and length 40 cm carries a load of 150 kN.The average bearing pressure is [IAS-1997]**

(a) 1.5 kN/cm^2 (b) 15 kN/cm^2 (c) 150 kN/cm^2 (d) none of the above

IAS-7Ans. (d) The average bearing pressure = $\frac{\text{load}}{\text{projected area}} = \frac{150}{25 \times 40} = 0.15 \text{kN/cm}^2$

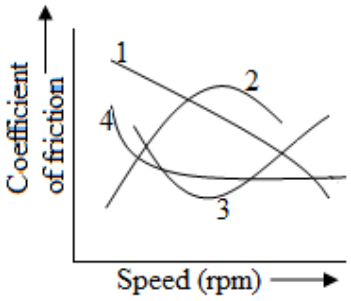
IAS-8. **Which one of the curves shown below represents the characteristic of a hydrodynamically lubricated journal bearing?**

(a) 1

(b) 2

(c) 3

(d) 4



[IAS-1998]

IAS-8Ans. (c)

IAS-9. Consider the following statements: [IAS-1996]
For a proper hydrodynamic lubrication for a given journal bearing.
1. the higher the viscosity, the lower the rotating speed needed to float the journal at a given load.
2. The higher the rotating speed, the higher the bearing load needed to float the journal at a given viscosity.
3. the higher the bearing load, the higher the viscosity needed to float the journal at a given speed.
Of these statements:
(a) 1, 2 and 3 are correct (b) 1 and 2 are correct
(c) 2 and 3 are correct (d) 1 and 3 are correct

IAS-9Ans. (a)

IAS-10. Assertion (A): An important feature of film lubrication is that once a lubricant film is formed on the mating surfaces by running the bearing with a lubricant having a high degree of oiliness, it is possible to change to a lubricant with a much lower oiliness. **[IAS-1999]**
Reason (R) Lubricants of high oiliness are liable to decompose or oxidize and hence are not suitable for general lubrication purposes.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IAS-10Ans. (a)

IAS-11. Thrust bearings of the sliding type are often provided with multiple sector-shaped bearing pads of the tilting type instead of a continuous angular bearing surface in order to [IAS 1994]
(a) Distribute the thrust load more non-uniformly
(b) Provide limited adjustments to shaft misalignments
(c) Enable the formation of a wedge shaped oil film
(d) Enable lubricating oil to come into contact with the total bearing area

IAS-11 Ans. (c)

Hydrostatic Step Bearing 464

IAS-12. The most suitable bearing for carrying very heavy loads with slow speed is
(a) Hydrodynamic bearing (b) ball bearing **[IAS 1994]**
(c) Roller bearing (d) hydrostatic bearing

IAS-12 Ans. (d)

Comparison of Rolling and Sliding Contact bearings

IAS-13. Match List -I (Bearings) with List-II (Applications) and select the correct answer using the codes given below the lists: [IAS-1998]

List –I	**List-II**
A. Journal bearing	**1. Electric motors**
B. Thrust bearing	**2. Watches**
C. Conical pivot bearing	**3. Marineengines**
D. Ball bearing	**4. Swivelling chairs**

Codes:	A	B	C	D		A	B	C	D
(a)	3	4	1	2	(b)	4	2	1	3
(c)	3	4	2	1	(d)	4	2	3	1

IAS-13Ans. (c)

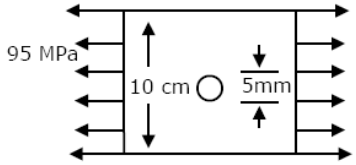
5. Fluctuating Load Consideration for Design

Objective Questions (IES, IAS, GATE)

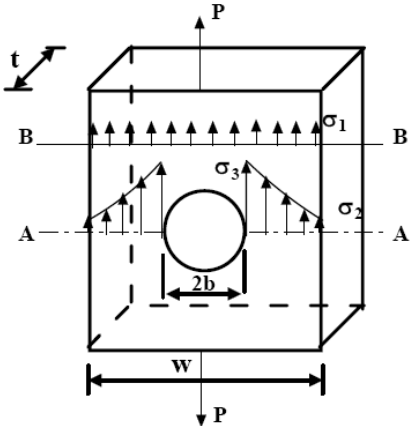
Previous 20-Yrs GATE Questions

GATE 1. A large uniform plate containing a rivet-hole is subjected to uniform uniaxial tension of 95 MPa. The maximum stress in the plate is[GATE-1992]

(a) 100 MPa
(b) 285 MFa
(c) 190 MFa
(d) Indeterminate



GATE 1. Ans. (b)



Stress concentration due to a central hole in a plate subjected to an uni-axial loading.

$\sigma_3 = \sigma_1\left(1+\frac{2b}{a}\right)$ If a=b the hole reduces to a circular one and therefore σ3 = 3σ1 which gives k_t =3.

GATE 2. Match 4 correct pairs between list I and List II for the questions [GATE-1994]

List I	List II
(a) Strain rosette	**1. Critical speed**
(b) Beams	**2. Mohr's circle**
(c) Section modulus	**3. Coil springs**
(d) Wahl's stress factor	**4. Flexural rigidity**
(e) Fatigue	**5. Endurance limit**
(f) Somerfield number	**6. Core section**

GATE 2. Ans. (a) – 2, (c) – 4, (d) – 3, (e) - 5

GATE 3. In terms of theoretical stress concentration factor (K_t) and fatigue stress concentration factor (K_f), then notch sensitivity 'q' is expressed as **[GATE-2004]**

(a) $\frac{(K_f - 1)}{(K_t - 1)}$ (b) $\frac{(K_f - 1)}{(K_t + 1)}$ (c) $\frac{(K_t - 1)}{(K_f - 1)}$ (d) $\frac{(K_f + 1)}{(K_t + 1)}$

GATE 3. Ans. (a)

GATE4. A thin supercritical pressure vessel of 200 mm diameter and 1 mm thickness is subjected to an internal pressure varying from 4 to 8 MPa. Assume that the yield, ultimate, and endurance strength of material are 600, 800 and 400 MPa respectively. The factor of safety as per Goodman's relation is **[GATE-2007]**

(a) 2.0 (b) 1.6 (c) 1.4 (d) 1.2

GATE 4. Ans. (b) Stress induced $\sigma_1 = \sigma_2 = \frac{pr}{2t}$

$$\sigma_{1max} = \frac{8 \times 100}{2 \times 1} = 400\,MPa$$

$$\sigma_{1min} = \frac{4 \times 100}{2 \times 1} = 200$$

$$\sigma_{2max} = 400\,MPa \qquad \sigma_{2min} = 200MPa$$

$$\sigma_{1m} = 300MPa \qquad \sigma_{1a} = 100MPa$$

$$\sigma_{2m} = 300MPa \qquad \sigma_{2a} = 100MPa$$

Equivalent Stresses

$$\sigma_{1me} = \sqrt{\sigma_{1m}^2 + \sigma_{2m}^2 - \sigma_{1m}\sigma_{2m}}$$
$$= \sqrt{300^2 + 300^2 - 300 \times 300}$$
$$= 300MPa$$

Similarly,

$$\Rightarrow \quad \frac{100}{400} + \frac{300}{800} = \frac{1}{n}$$
$$n = 1.6$$

GATE 5. A forged steel link with uniform diameter of 30 mm at the centre is subjected to an axial force that varies from 40 kN in compression to 160 kN in tension. The tensile (S_u), yield (S_y,) and corrected endurance (S_e) strength of the steel material are 600 MPa, 420 MPa and 240 MPa respectively. The factor of safety against fatigue endurance as per Soderberg's criterion is **[GATE -2009]**

(a) 1.26 (b) 1.37 (c) 1.45 (d) 2.00

GATE 5. Ans. (a) $\sigma_{max} = \frac{160 \times 10^3\,N}{\frac{\pi \times 30^2}{4}\,mm^2} = 226\,MPa$

$$\sigma_{min} = \frac{-40\times10^3\,\text{N}}{\frac{\pi\times30^2}{4}\,\text{mm}^2} = -56.6\,\text{MPa}$$

$$\sigma_{mean} = \frac{(\sigma_{max}+\sigma_{min})}{2} = 84.7\,\text{MPa}$$

$$\sigma_{min} = \frac{(\sigma_{max}-\sigma_{min})}{2} = 141.3\,\text{MPa}$$

Therefore $\frac{1}{FOS} = \frac{\sigma_{mean}}{\sigma_y} + \frac{\sigma_v}{\sigma_e}$

or $\frac{1}{FOS} = \frac{84.7}{420} + \frac{141.3}{240}$

or $FOS = 1.26$

GATE 6. The yield strength of a steel shaft is twice its endurance limit. Which of the following torque fluctuation represent the most critical situation according to Soderberg criterion? [GATE-1993]

(a) -T to +T (b) -T/2 to +T (c) 0 to +T (d) +T/2 to +T

GATE 6. Ans. (a)

GATE 7. An aeroplane makes a half circle towards left. The engine runs clockwise when viewed from the rear. Gyroscopic effect on the aeroplane causes the nose to [GATE-1995]

(a) Lift (b) dip (c) both Lift and dip (d) None of the above

GATE 7. Ans. (a)

GATE 8. For a disk of moment of inertia I the spin and precession angular velocities are ω and ω_p respectively. The magnitude of gyroscopic couple is..... [GATE-1994]

(a) $I\omega\omega_p$ (b) $I\omega\omega_p / 2$ (c) $2I\omega\omega_p$ (d) $4I\omega\omega_p$

GATE 8. Ans. (a)

GATE 9. The S-N curve for steel becomes asymptotic nearly at [GATE-2004]

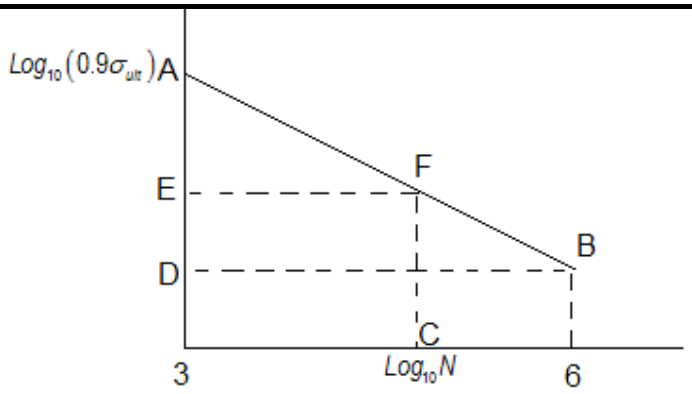
(a) 10^3 cycles (b) 10^4 cycles (c) 10^6 cycles (d) 10^9 cycles

GATE 9. Ans. (c)

GATE10. A cylindrical shaft is subjected to an alternating stress of 100 MPa. Fatigue strength to sustain 1000 cycles is 490 MPa. If the corrected endurance strength is 70 MPa, estimated shaft life will be [GATE-2006]

(a) 1071 cycles (b) 15000 cycles (c) 281914 cycles (d) 928643 cycles

GATE 10. Ans. (c)



It is a finite life problem. The line AB is the failure line. Where $A\{3, \log_{10}(0.9\sigma_{ult})\}$ but here it will be $A\{3, \log_{10}(490)\}$ and $B\{6, \log_{10}(\sigma_e)\}$ here it is $B\{6, \log_{10}(70)\}$ Therefore $F\{, \log_{10} N, \log_{10}(100)\}$ we have to find N

$$\frac{EF}{AE} = \frac{DB}{AD}$$

Or $$\frac{\log_{10} N - 3}{\log_{10} 490 - \log_{10} 100} = \frac{6-3}{\log_{10} 490 - \log_{10} 70}$$

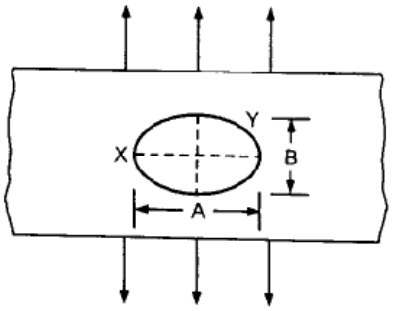
or N = 281914 cycles.

Previous 20-Yrs IES Questions

Stress Concentration

IES 1. **A loaded semi-infinite flat plate is having an elliptical hole (A/B = 2) in the middle as shown in the figure. The stress concentration factor at points either X or Y is**

(a) 1
(b) 3
(c) 5
(d) 7



[IES-2000]

IES 1. Ans. (c)

Fluctuating Stresses

IES 2. **In designing a shaft for variable loads, the S.N. diagram can be drawn by**

(a) Joining the S_{ut} at 0 cycles and S_e at 10^6 cycles by a straight line on an S.N. graph
(b) Joining the 0.9 S_{ut} at 1000 cycles and S_e at 10^6 cycles by a straight line on a log S- log N graph **[IES 2007]**
(c) Joining the 0.9 S_{ut} at 1000 cycles and S_e at 10^6 cycles by a straight line on an S-N graph
(d) Joining the S_{ut} at 1000 cycles and 0.9 S_e at 10^6 cycles by a straight line on a log S- log N graph

(S_{ut} stands for ultimate tensile strength and $S_{e\ for}$ the endurance limit)

IES 2. Ans. (b)

IES 3. Consider the following statements: [IES-2005]

1. **Endurance strength of a component is not affected by its surface finish and notch sensitivity of the material.**
2. **For ferrous materials like steel, S-N curve becomes asymptotic at 10^6 cycles.**

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2

IES 3. Ans. (b) 1 is false: affected

Endurance Limit

IES 4. Match List I with List II and select the correct answer using the codes given below the lists: [IES-1993]

List I (Material properties)	**List II(Tests to determine material properties)**
A. Ductility	**1. Impact test**
B. Toughness	**2. Fatigue test**
C. Endurance limit	**3. Tension test**
D. Resistance to penetration	**4. Hardness test**

Code:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	3	2	1	4	(b)	4	2	1	3
(c)	3	1	2	4	(d)	4	1	2	3

IES 4. Ans. (c)

IES 5. When σ and Young's Modulus of Elasticity E remain constant, the energy-absorbing capacity of part subject to dynamic forces, is a function of its [IES-1992]

(a) Length (b) cross-section (c) volume (d) none of the above

IES 5. Ans. (c) Strain energy is given by,

$$U = A.L.\left(\frac{\sigma^2}{2E}\right)$$

Where σ and E remaining constant,

$\therefore$ U is proportional to (A.L.) which is volume.

Also, since U is a function of σ^2, that portion of the part which is prone to high localised will absorb a high amount of energy, making it vulnerable to failure. Such a part, therefore, is designed to have such a contour that, when it is subjected to time-varying or impact loads or others types of dynamic forces, the part absorbs or less uniform stress distribution along the whole length of the part is ensured.

IES 6. Fatigue strength of a rod subjected to cyclic axial force is less than that of a rotating beam of the same dimensions subjected to steady lateral force. What is the reason? [IES-2009]

(a) Axial stiffness is less than bending stiffness

(b) Absence of centrifugal effects in the rod

(c) The number of discontinuities vulnerable to fatigue is more in the rod

(d) At a particular time, the rod has only one type of stress whereas the beam has both tensile and compressive stresses

IES 6. Ans. (d)

Soderberg and Goodman Diagrams

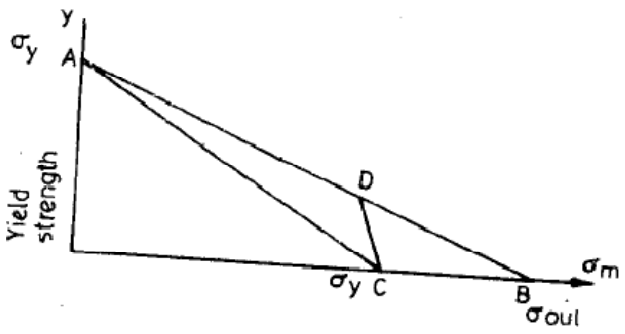
IES 7. **Assertion (A):** Soderberg relation is used for design against fatigue. **[IES-1996]**
Reason (R): Soderberg relation is based on yield strength of the material whereas all other failure relations for dynamic loading are based on ultimate strength of the material.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES 7. Ans. (a)

IES 8. **The design calculations for members subject to fluctuating loads with the same factor of safety yield the most conservative estimates when using**
(a) Gerber relation (b) Soderberg relation **[IES-1995]**
(c) Goodman relation (d) none of the above.

IES 8. Ans. (b)

IES 9. **In the figure shown, it the line AB represents Goodman criterion of failure, then soderberg criterion could be represented by line**
(a) AD
(b) D
(c) DC
(d) AC



[IES-1992]

IES 9. Ans. (d)

Gyroscopic motion

IES 10. **Consider the following statements:** **[IES-2005]**
1. **The effect of gyroscopic couple on a car while negotiating a curve is that its outer wheels tend to get lifted from the ground.**
2. **If spin vector is rotated about the precession vector axis in a direction opposite to that of precession through 90°, the new position of the spin vector indicates the direction of the torque vector.**

Which of the following statements given above is/are correct?
(a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2

IES 10. Ans. (d)

IES 11. **Assertion (A):** The precession of the axis of rotation of a shaft causes a gyroscopic reaction couple to act on the frame to which the bearings are fixed.
Reason (R): The reaction of the shaft on each bearing is equal and opposite to the action of the bearing on the shaft. **[IES-2002]**
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES 11. Ans. (b)

IES 12. **Assertion (A):** There is a danger of locomotive wheels being lifted above rails at certain speeds. **[IES-2001]**

Reason (R): Lifting of the locomotive wheel above rails at certain speed is due to gyroscopic action.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IES 12. Ans. (c)

Previous 20-Yrs IAS Questions

IAS 1. **A flywheel has a mass of 300 kg and a radius of gyration of 1m. It is given a spin of 100 r.p.m about its horizontal axis. The whole assembly rotates about a vertical axis at 6 rad/sec. The gyroscopic couple experienced will be** **[IAS-1996]**
(a) 3π kNm (b) 6π kNm (c) 180π kNm (d) 360π kNm

IAS 1. Ans. (b)

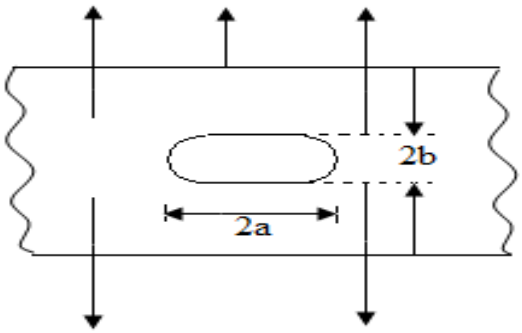
Gyroscopic couple = $I\omega\omega_p = mk^2\omega\omega_p = 300\times1^2\times\left(\frac{2\pi\times100}{60}\right)\times6\ \text{Nm} = 6\pi\text{KNm}$

IAS 2. **A bicycle remains stable in running through a bend because of** **[IAS 1994]**
(a) Gyroscopic action (b) Corioli's acceleration
(c) centrifugal action (d) radius of curved path

IAS 2. Ans. (a)

IAS 3. **In a semi-infinite flat plate shown in the figure, the theoretical stress concentration factor k_t for an elliptical hole of major axis 2a and minor axis 2b is given by**

(a) $K_t = \frac{a}{b}$
(b) $K_t = 1+\frac{a}{b}$
(c) $K_t = 1+\frac{2b}{a}$
(d) $K_t = 1+\frac{2a}{b}$



[IAS-1998]

IAS 3. Ans. (d)

IAS 4. **Assertion (A):** Endurance limits for all materials are always less than the ultimate strength of the corresponding materials. **[IAS 1994]**
Reason (R): Stress concentration in a machine part due to any dislocation is very damaging when the part is subjected to variable loading.
(a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is **not** the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

IAS 4. Ans. (b)

IAS 5. **Match List I (Mechanical Property) with List II (Measured in Terms of) and select the correct answer using the codes given below the lists:**
List-I **List-II** **[IAS-2003]**

(Mechanical Property)	(Measured in Terms of)
(A) Strength (Fluctuating load)	1. Percentage elongation
(B) Toughness	2. Modulus of elasticity
(C) Stiffness	3. Endurance limit
(D) Ductility	4. Impact strength

Codes:	A	B	C	D		A	B	C	D
(a)	2	1	3	4	(b)	3	4	2	1
(c)	2	4	3	1	(d)	3	1	2	4

IAS 5. Ans. (b)

IAS 6. Match List I with List II and select the correct answer: [IAS-2000]

List I	List II
A. Proof stress	1. Torsion test
B. Endurance limit	2. Tensile test
C. Leaf Spring	3. Fatigue test
D. Modulus of rigidity	4. Beam of uniform strength

	A	B	C	D		A	B	C	D
(a)	2	3	4	1	(b)	2	3	1	4
(c)	3	2	4	1	(d)	3	2	1	4

IAS 6. Ans. (a)

6. Miscellaneous

Objective Questions (For GATE, IES & IAS)

Previous 20-Yrs GATE Questions

GATE-1. In a 2-D CAD package, clockwise circular arc of radius 5, specified from P_1 (15, 10) to P_2(10, 15) will have its center at [GATE-2004]

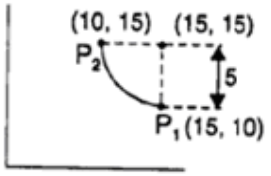
(a) (10, 10) (b) (15, 10) (c) (15, 15) (d) (10, 15)

GATE-1. Ans. (c)

Given: P_1 (15,10)

P_2 (10,15)

Clearly from figure,
Centre of are having radius
= 5 is (15, 15)



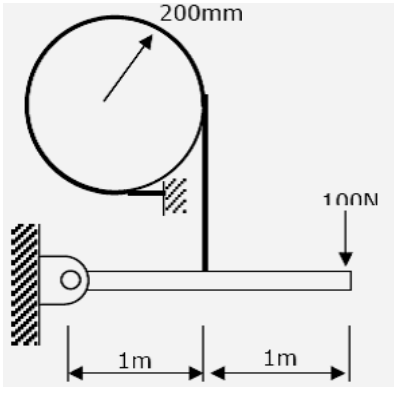
GATE-2. A band brake having band-width of 80 mm, drum diameter of 250 mm, coefficient of friction of 0.25 and angle of wrap of 270 degrees is required to exert a friction torque of 1000 N m. The maximum tension (in kN) developed in the band is [GATE-2010]

(a) 1.88 (b) 3.56 (c) 6.12 (d) 11.56

GATE-2. Ans. (d)

Statement for Linked Answer GATE- 3 and GATE-4:

A band brake consists of a lever attached to one end of the band. The other end of the band is fixed to the ground. The wheel has a radius of 200 mm and the wrap angle of the band is 270°. The braking force applied to the lever is limited to 100 N, and the coefficient of friction between the band and the wheel is 0.5. No other information is given.



GATE-3. The maximum tension that can be generated in the band during braking is [GATE-2005]

(a) 1200 N (b) 2110 N (c) 3224 N (d) 4420 N

GATE-3. Ans. (b)

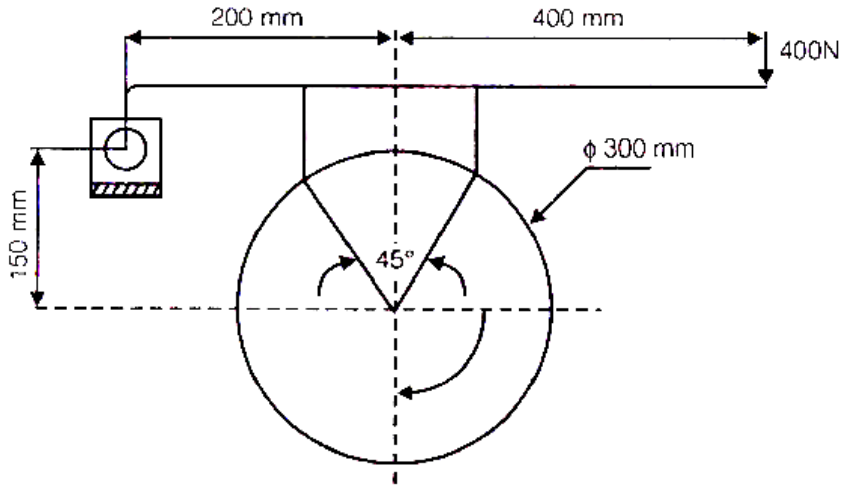
Taking moment about hinge

$T_2 \times 1 = 100 \times 2$

GATE-4. The maximum wheel torque that can be completely braked is [GATE-2005]
(a) 200 N.m (b) 382 N.m (c) 604 N.m (d) 844 N.m
GATE-4. Ans. (b)

GATE-5. In a band brake the ratio of tight side band tension to the tension on the slack side is 3. If the angle of overlap of band on the drum is 180° the coefficient of friction required between drum and the band is [GATE-2003]
(a) 0.20 (b) 0.25 (c) 0.30 (d) 0.35
GATE-5. Ans. (d)

GATE-6. A block-brake shown below has a face width of 300 mm and a mean coefficient of friction of 0.25. For an activating force of 400 N, the braking torque in Nm is [GATE-2007]



(a) 30 (b) 40 (c) 45 (d) 60
GATE-6. Ans. (c)

Previous 20-Yrs IES Questions

IES-1. What is the correct sequence of the following steps in engine analysis?
1. Vibration analysis 2. Inertia force analysis. [IES-1997]
3. Balancing analysis 4. Velocity and Acceleration analysis.
Select the correct answer using the codes given below:
(a) 2, 4, 1, 3 (b) 2, 4, 3, 1 (c) 4, 2, 1, 3 (d) 4, 2, 3, 1
IES-1. Ans. (c)

IES-2. A device for lifting or lowering objects suspended from a hook at the end of a retractable chain or cable is called [IES-1994; 1995]
(a) Hoist (b) jib crane (c) chain conveyor (d) elevator
IES-2. Ans. (a)

IES-3. Consider the following design considerations: [IES-1995]
1. Tensile failure 2. Creep failure 3. Bearing failure
4. Shearing failure 5. Bending failure
The design of the pin of a rocker arm of an I.C. engine is based on
(a) 1, 2 and 4 (b) 1, 3 and 4 (c) 2, 3 and 5 (d) 3, 4 and 5.
IES-3. Ans. (d) Design of pin of a rocker arm of an I.C. engine is based on bearing, shearing,

IES-4. Consider the following statements regarding the differential of an automobile: [IES-1994]
1. The speed of the crown wheel will always be the mean of the speeds of the two road wheels.
2. The road wheel speeds are independent of the number of teeth on the planets.
3. The difference between the speeds of the road wheels depends on the number of teeth on the planets.
4. The ratio of speeds of the road wheels depends upon the number of teeth on the gear wheels attached to them and on the crown wheel.
Of these statements
(a) 1 and 2 are correct (b) 3 and 4 are correct
(c) 1 and 3 are correct (d) 2 and 4 are correct.

IES-4. Ans. (d)

IES-5. Interchangeability can be achieved by [IES-1993]
(a) Standardisation (b) better process planning
(c) Simplification (d) better product planning

IES-5. Ans. (a) Interchangeability can be achieved by standardisation.

IES-6. In an automobile service station, an automobile is in a lifted up position by means of a hydraulic jack. A person working in the service station gave a tap to one rear wheel and made it rotate by one revolution. The rotation of another rear wheel is [IES-1993]
(a) Zero
(b) Also one revolution in the same direction
(c) Also one revolution but in the opposite direction
(d) unpredictable

IES-6. Ans. (a) When one rear wheel is rotated, other is free.

IES-7. Which of the following stresses are associated with the tightening of a nut on a stud?
1. Tensile stresses due to stretching of stud.
2. Bending stresses of stud. [IES-1993]
3. Transverse shear stresses across threads.
4. Torsional shear stresses in threads due to frictional resistance.
Select the correct answer using the codes given below:
(a) 1, 2 and 3 (b) 1, 2 and 4 (c) 2, 3 and 4 (d) 1, 3 and 4

IES-7. Ans. (a)

IES-8. Match the following [IES-1992]

List -I (Dynamometer)	List – II (Characteristics)
A. Torsion Dynamometer	1. High speeds and low power
B. Tesla fluid friction dynamometer	2. Power absorbed independent of size of flywheel.
C. Prony brake	3. Power absorbed available for useful applications
D. Swinging field dynamometer	4. Large powers

IES-8. Ans. (d)

Previous 20-Yrs IAS Questions

IAS-1. Rope brake dynamometer uses **[IAS-2001]**

(a) Water as lubricant (b) oil as lubricant
(c) Grease as lubricant (d) no lubricant

IAS-1. Ans. (d)

IAS-2. Consider the following statements regarding power:
1. It is the capacity of a machine. **[IAS-1997]**
2. The efficiency is always less than unity as every device operates with some loss of energy.
3. A dynamometer can measure the power by absorbing it.
4. Watt-hour is the unit of power.
Of these statements:

(a) 1, 2 and 3 are correct (b) 2, 3 and 4 correct
(c) 1, 3 and 4 are correct (d) 1, 2 and 4 are correct

IAS-2. Ans. (a)