S K Mondal's

IC Engine

GATE, IES & IAS 20 Years Question Answers

Contents

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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. Gas Power Cycles

OBJECTIVE QUESTIONS (GATE, IES, IAS)

Previous Years GATE Questions

Carnot cycle

Q1. A cyclic heat engine does 50 kJ of work per cycle. If the efficiency of the heat engine is 75%, the heat rejected per cycle is [GATE-2001]

(a) $16\frac{2}{3}$ kJ (b) $33\frac{1}{3}$ kJ (c) $37\frac{1}{2}$ kJ (d) $66\frac{2}{3}$ kJ

Q2. A Carnot cycle is having an efficiency of 0.75. If the temperature of the high temperature reservoir is 727° C/ what is the temperature of low temperature reservoir? [GATE-2002]

(a) 23°C (b) -23°C (c) 0°C (d) 250°C

Q3. A heat transformer is a device that transfers a part of the heat, supplied to it at an intermediate temperature, to a high temperature reservoir while rejecting the remaining part to a low temperature heat sink. In such a heat transformer, 100 kJ of heat is supplied at 350 K. The maximum amount of heat in kJ that can be transferred to 400 K, when the rest is rejected to that can be transferred to 400 K, when rest is rejected to a heat sink at 300 K is

(a) 12.50 (b) 14.29 (c) 33.33 (d) 57.14 **[GATE-2007]**

Q4. A solar energy based heat engine which receives 80 kJ of heat at 100 deg C and rejects 70 kJ of heat to the ambient at 30 deg C is to be designed. The thermal efficiency of the heat engine is [GATE-1996]

(a) 70% (b) 1.88% (c) 12.5% (d) indeterminate

Stirling cycle

Q5. A Stirling cycle and a Carnot cycle operate between 50°C and 350°C. Their efficiencies are η_s and η_c respectively. In this case, which of the following statements is true? [GATE-1999]

(a) $\eta_s > \eta_c$ (b) $\eta_s = \eta_c$
(c) $\eta_s < \eta_c$
(d) The sign of $(\eta_s - \eta_c)$ depends on the working fluids used

Ericsson cycle

Q6. A cycle consisting of two reversible isothermal processes and two reversible isobaric processes is known as [GATE-1996]

(a) Atkinson cycle (b) Stirling cycle
(c) Brayton cycle (d) Ericsson cycle

Q7. A gas turbine cycle with infinitely large number of stages during compression and expansion leads to [GATE-1994]

(a) Stirling cycle (b) Atkinson cycle
(c) Ericsson cycle (d) Brayton cycle

The constant volume or Otto cycle

Q8. Which one of the following is NOT a necessary assumption for the air-standard Otto cycle?
(a) All processes are both internally as well as externally reversible.
(b) Intake and exhaust processes are constant volume heat rejection processes.
(c) The combustion process is a constant volume heat addition process.
(d) The working fluid is an ideal gas with constant specific heats. **[GATE-2008]**

Q9. An engine working on air standard Otto cycle has a cylinder diameter of 10 cm and stroke length of 15 cm. The ratio of specific heats for air is 1.4. If the clearance volume is 196.3 cc and the heat supplied per kg of air per cycle is 1800kJ/kg, then work output per cycle per kg of air is [GATE-2004]
(a) 879.1 kJ (b) 890.2 kJ
(c) 895.3 kJ (d) 973.5 kJ

Q10. For an engine operating on air standard Otto cycle, the clearance volume is 10% of the swept volume. The specific heat ratio of air is 1.4. The air standard cycle efficiency is [GATE-2003]
(a) 38.3% (b) 39.8% (c) 60.2% (d) 61.7%

Q11. An ideal air standard Otto cycle has a compression ratio of 8.5. If the ratio of the specific heats of (y) is 1.4/ then what is the thermal efficiency (in percentage) of the Otto cycle? [GATE-2002]
(a) 57.5 (b) 45.7 (c) 52.5 (d) 95

Q12. In an air-standard Otto cycle, the compression ratio is 10. The condition at the beginning of the compression process is 100 kPa and 27^{0}C. Heat added at constant volume is 1500 kJ/kg, while 700 kJ/kg of heat is rejected during the other constant volume process in the cycle. Specific gas constant for air = 0.287 kJ/kgK. The mean effective pressure (in kPa) of the cycle is [GATE -2009]
(a) 103 (b) 310 (c) 515 (d) 1032

Q13. In a spark ignition engine working on the ideal Otto cycle, the compression ratio is 5.5. The work output per cycle (i.e., area of the P-V diagram) is equal to 23.625 x 10^5 x V_c J, where V_c is the clearance volume in m^3. The indicated mean effective pressure is [GATE-2001]
(a) 4.295 bar (b) 5.250 bar
(c) 86.870 bar (d) 106.300 bar

Comparison of Otto, diesel, and dual (limited-pressure) cycles

Q14. [GATE-1995]

List l (Heat Engines)	List II (Cycles)
(A) Gas Turbine	**1. Constant volume heat addition and constant volume heat rejection**
(B) Petrol Engine	**2. Constant pressure heat addition and constant volume heat rejection**
(C) Stirling Engine	**3. Constant pressure heat addition and constant pressure heat rejection**

(D) Diesel Engine				**4. Heat addition at constant volume followed by heat addition at constant temperature**				
				5. Heat rejection at constant volume followed by heat rejection at constant temperature				
	A	**B**	**C**	**D**	**A**	**B**	**C**	**D**
(a)	3	1	4	2	(b) 1	4	2	3
(c)	4	2	3	1	(d) 2	3	1	4

Common Data for Questions 15 & 16:

In two air standard cycles - one operating on the Otto and the other on the Brayton cycle-air is isentropic ally compressed from 300 to 450 K. Heat is added to raise the temperature to 600 K in the Otto cycle and to 550 K in the Brayton cycle.

Q15. If η_o and η_B are the efficiencies of the Otto and Brayton cycles, then

(a) $\eta_o = 0.25, \quad \eta_B = 0.18$ **[GATE-2005]**

(b) $\eta_o = \eta_B = 0.33$

(c) $\eta_o = 0.5, \quad \eta_B = 0.45$

(d) It is not possible to calculate the efficiencies unless the temperature after the expansion is given

Q16. If W_o and W_B are work outputs per unit mass, then **[GATE-2005]**

(a) $W_o > W_B$
(b) $W_O < W_B$
(c) $W_O = W_B$
(d) it is not possible to calculate the work outputs unless the temperature after expansion is Given.

Q17. A diesel engine is usually more efficient than a spark ignition engine because

(a) diesel being a heavier hydrocarbon, releases more heat per kg than gasoline
(b) The air standard efficiency of diesel cycle is higher than the Otto cycle, at a fixed compression ratio **[GATE-2003]**
(c) The compression ratio of a diesel engine is higher than that of an SI engine
(d) Self ignition temperature of diesel is higher than that of gasoline

Q18. Consider air standard Otto and Diesel cycles, both having the same state of air at the start of compression. If the maximum pressure in both the cycles is the same, then compression ratio 'r' and the efficiency 'η' are related by

(a) $r_{Diesel} > r_{Otto}$ (b) $r_{Diesel} < r_{Otto}$
(c) $\eta_{Otto} > \eta_{Diesel}$ (d) $\eta_{Otto} < \eta_{Diesel}$ **[GATE-2000]**

Previous Years IES Questions

Carnot cycle

Q1. Which gas power cycle consists of four processes during which work alone is transferred and heat alone is transferred during the other two processes?

(a) Atkinson cycle (b) Carnot cycle **[IES-2008]**
(c) Diesel cycle (d) Otto cycle

Q2. Three engines A, B and C operating on Carnot cycle use working substances as Argon, Oxygen and Air respectively. Which engine will have higher efficiency? **[IES-2009]**

(a) Engine A (b) Engine B

(c) Engine C (d) All engines have same efficiency

Q3. Which one of the following cycles has the highest thermal efficiency for given maximum and minimum cycle temperatures? [IES-2005]
(a) Brayton cycle (b) Otto cycle
(c) Diesel cycle (d) Stirling cycle

Q4. For a heat engine operating on the Carnot cycle, the work output is ¼ th of the heat transferred to the sink. The efficiency of the engine is [IES-2003]
(a) 20 % (b) 33.3 % (c) 40 % (d) 50 %

Q5. The data given in the table refers to an engine based on Carnot cycle, where Q_1 = Heat received (kJ/min), Q_2 = Heat rejected (kJ/s), W = Work output (kW)

S. No.	Q_1	Q_2	W
1.	1500	16.80	8.20
2.	1600	17.92	8.75
3.	1700	19.03	9.30
4.	1800	20.15	9.85

If heat received by the engine is 2000 kJ/minute the work output will be, nearly, [IES-2001]
(a) 9.98 (b) 10.39 (c) 11.54 (d) 10.95

Q6. A Carnot engine uses nitrogen as the working fluid (γ = 1.4). The heat supplied is 52 kJ and adiabatic expansion ratio 32:1. The receiver temperature is 295 K. What is the amount of heat rejected? [IES 2007]
(a) 11 kJ (b) 13 kJ (c) 26 kJ (d) 28 kJ

Q7. In a heat engine operating in a cycle between a source temperature of 606°C and a sink temperature of 20°C, what will be the least rate of heat rejection per kW net output of the engine? [IES-2004]
(a) 0.50 kW (b) 0.667 kW (c) 1.5 kW (d) 0.0341 kW

Q8. Which one of the following changes/sets of changes in the source and sink temperatures (T_1 and T_2 respectively) of a reversible engine will result in the maximum improvement in efficiency?
(a) $T_1 + \Delta T$ (b) $T_2 - \Delta T$
(c) $T_1 + \Delta T$ and $T_2 - \Delta T$ (d) $T_1 - \Delta T$ and $T_2 - \Delta T$ **[IES-1994]**

Q9. A heat engine using lake water at 12°C as source and the surrounding atmosphere at 2 °C as sink executes 1080 cycles per min. If the amount of heat drawn per cycle is 57 J, then the output of the engine will be [IES-1993]
(a) 66W (b) 56W (c) 46 W (d) 36 W

Stirling cycle

Q10. What does the reversed ideal Stirling cycle consist of? [IES-2005]
(a) Tow reversible isothermal processes and two reversible adiabatic processes
(b) Two reversible isothermal processes and two reversible isochoric processes
(c) Two reversible isobaric processes and two reversible adiabatic processes
(d) Two reversible adiabatic processes and two reversible isochoric processes

Q11.

Thermodynamic cycle shown above on the temperature – entropy diagram pertains to which one of the following?

(a) Stirling cycle (b) Ericsson cycle
(c) Vapour compression cycle (d) Brayton cycle **[IES 2007]**

Ericsson cycle

Q12. Which cycle consists of two reversible isotherms and two reversible isobars?

(a) Carnot cycle (b) Stirling cycle
(c) Ericsson cycle (d) Brayton cycle **[IES-2009]**

Q13. Which one of the following parameters is significant to ascertain chemical equilibrium of a system? **[IES-2009]**

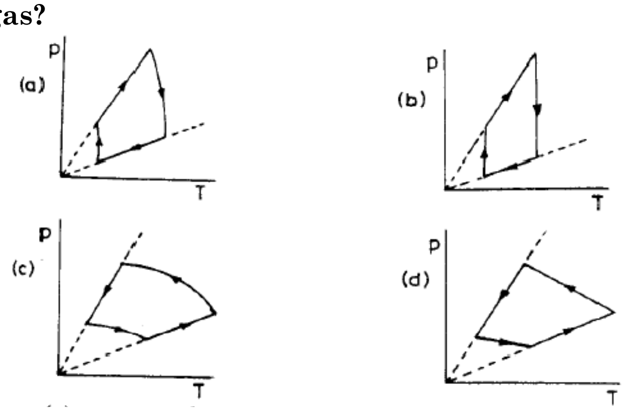
(a) Clapeyron relation (b) Maxwell relation
(c) Gibbs function (d) Helmholtz function

Q14. Brayton cycle with infinite inter-cooling and reheating stages would approximate a **[IES-2002]**

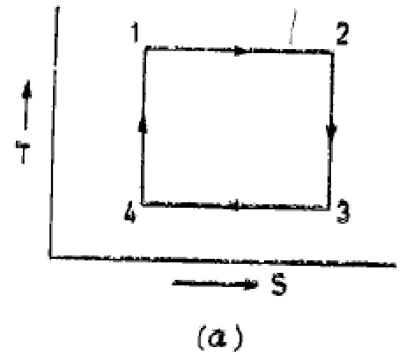
(a) Stirling cycle (b) Ericsson cycle
(c) Otto cycle (d) Atkinson cycle

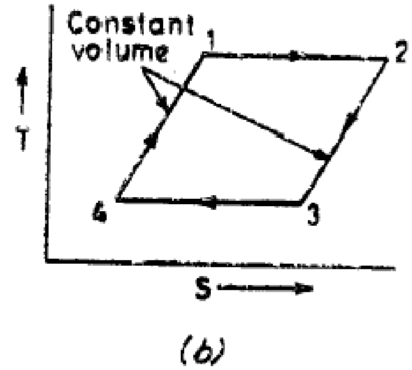
The constant volume or Otto cycle

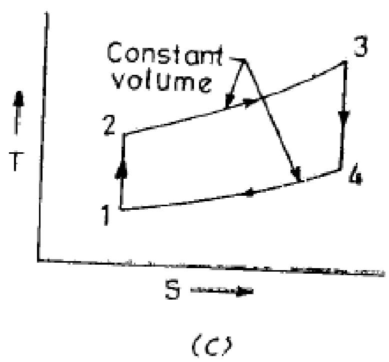
Q15. Which one of the following p-T diagrams illustrates the Otto cycle of an ideal gas? **[IES-1996]**

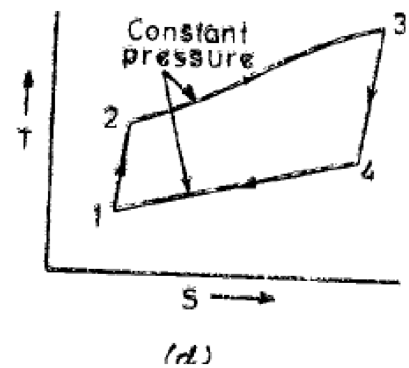


Q16. Which one of the following diagrams represents Otto cycle on temperature (T) - entropy (s) plane? **[IES-1993]**



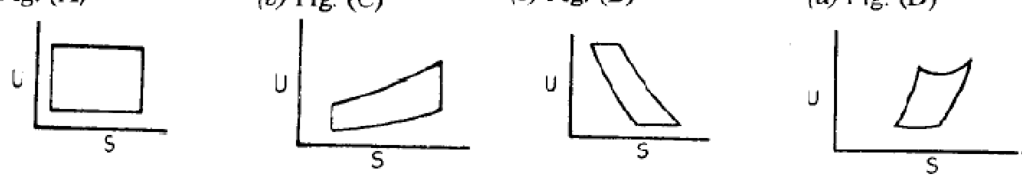






Q17. An Otto cycle on internal energy (U) and entropy(s) diagram is shown in **[IES-1992]**

(a) Fig. (A) (b) Fig. (C) (c) Fig. (B) (d) Fig. (D)



Q18. Consider the following statements regarding Otto cycle: **[IES-1998]**
1. It is not a reversible cycle.
2. Its efficiency can be improved by using a working fluid of higher value of ratio of specific heats.
3. The practical way of increasing its efficiency is to increase the compression ratio.
4. Carburetted gasoline engines working on Otto cycle can work with compression ratios more than
Of these statements
(a) 1, 3 and 4 are correct (b) 1, 2 and 3 are correct
(c) 1, 2 and 4 are correct (d) 2, 3 and 4 are correct

Q19. For maximum specific output of a constant volume cycle (Otto cycle)
(a) The working fluid should be air **[IES-1997]**
(b) The speed should be high
(c) Suction temperature should be high
(d) Temperature of the working fluid at the end of compression and expansion should be equal

Q20. In an air standard Otto cycle, r is the volume compression ratio and y is an adiabatic index (C_p/ C_v), the air standard p v efficiency is given by **[IES-2002]**

(a) $\eta = 1 - \frac{1}{r^{\gamma-1}}$ (b) $\eta = 1 - \frac{1}{r^{\gamma}}$

(c) $\eta = 1 - \frac{1}{r^{\frac{\gamma-1}{\gamma}}}$ (d) $\eta = 1 - \frac{1}{r^{\frac{\gamma-1}{2\gamma}}}$

Q21. For the same maximum pressure and heat input, the most efficient cycle is
(a) Otto cycle (b) Diesel cycle **[IES-2000]**
(c) Brayton cycle (d) Dual combustion cycle

Q22. Assertion (A): Power generated by a four stroke engine working on Otto cycle is higher than the power generated by a two stroke engine for the same swept volume, speed, temperature and pressure conditions. **[IES-2003]**
Reason (R): In a four stroke engine one cycle is completed in two revolutions.
(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

The diesel cycle

Q23. Consider the following statements: [IES-2006]
1. **For a Diesel cycle, the thermal efficiency decreases as the cut off ratio increases.**
2. **In a petrol engine the high voltage for spark is in the order of 1000 V**
3. **The material for centre electrode in spark plug is carbon.**

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

Q24. In an air-standard Diesel cycle, r is the compression ratio, p is the fuel cut - off ratio and y is the adiabatic index (C_p/ C_v). Its air standard efficiency is given by [IES-2002]

(a) $\eta = 1 - \left[\frac{1}{\gamma r^{\gamma}} . \frac{(\rho^{\gamma} - 1)}{(\rho - 1)}\right]$ (b) $\eta = 1 - \left[\frac{1}{\gamma r^{\gamma-1}} . \frac{(\rho^{\gamma-1} - 1)}{(\rho - 1)}\right]$

(c) $\eta = 1 - \left[\frac{1}{\gamma r^{\gamma-1}} . \frac{(\rho^{\gamma} - 1)}{(\rho - 1)}\right]$ (d) $\eta = 1 - \left[\frac{1}{\gamma r^{\gamma}} . \frac{(\rho^{\gamma-1} - 1)}{(\rho - 1)}\right]$

Q25. Assertion (A): The air standard efficiency of the diesel cycle decreases as the load is increased
Reason (R): With increase of load, cut-off ratio increases. **[IES-2001]**
(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

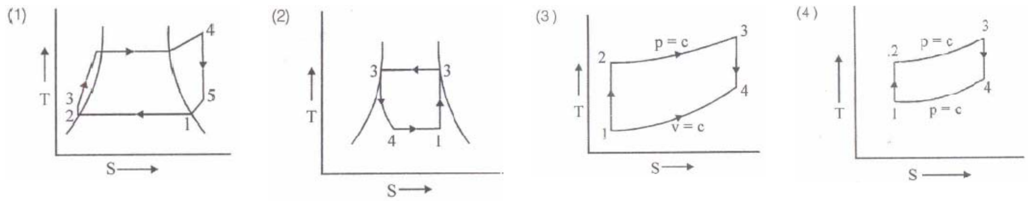
The dual or mixed or limited pressure cycle

Q26. In a standard dual air cycle, for a fixed amount of heat supplied and a fixed value of compression ratio, the mean effective pressure [IES-2003]
(a) Shall increase with increase in r_p (pressure ratio for constant volume heating) and decrease in r_c (constant pressure cut-off ratio)
(b) Shall increase with decrease in r_p and increase in r_c

(c) Shall remain independent of r_p
(d) Shall remain independent of r_c

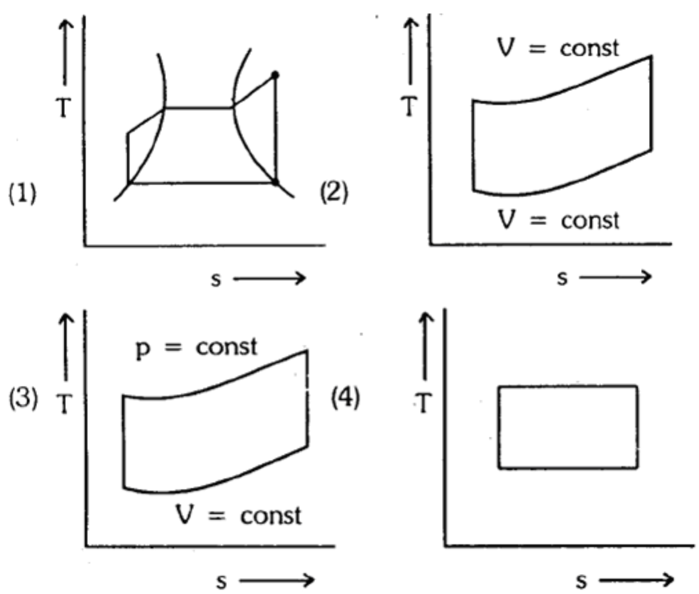
Comparison of Otto, diesel, and dual (limited-pressure) cycles

Q27.



The correct sequence of the cycles given in the above T-S diagrams is
(a) Vapour compression refrigeration, Rankine, Diesel, Otto **[IES-2003]**
(b) Rankine, Vapour compression refrigeration, Diesel, Brayton
(c) Rankine, Carnot, Otto, Brayton
(d) Vapour compression refrigeration, Carnot, Diesel, Otto

Q28.



The correct sequence of the given four cycles on T-s plane in Figure (1), (2), (3), (4) is **[IES-2002]**
(a) Rankine, Otto, Carnot and Diesel
(b) Rankine, Otto, Diesel and Carnot
(c) Otto, Rankine, Diesel and Carnot
(d) Otto, Rankine, Carnot and Diesel

Q29. For the same maximum pressure and heat input **[IES-1992]**
(a) The exhaust temperature of patrol is more than that of diesel engine
(b) The exhaust temperature of diesel engine is more than that of patrol engine
(c) The exhaust temperature of dual cycle engine is less than that of diesel engine
(d) The exhaust temperature of dual cycle engine is more than that of patrol engine

Q30. Match List I with II and select the correct answer using the code given below the **[IES 2007]**
Lists:

List I	**List II**
(Prime Mover)	**(Air Standard Cycle)**
A. High Speed diesel engine	**1. Atkinson Cycle**
B. IC engine having expansion ratio greater than compression ratio	**2. Dual combustion limited pressure cycle**

C. Pulse jet engine	**3. Erickson Cycle**
D. Gas turbine with multistage compression and multistage expansion	**4. Lenoir cycle**

Code:

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

Q31. The order of values of thermal efficiency of Otto, Diesel and Dual cycle, when they have equal compression ratio and heat rejection, is given by [IES-2002]

(a) $\eta_{otto} > \eta_{diesel} > \eta_{dual}$
(b) $\eta_{diesel} > \eta_{dual} > \eta_{otto}$
(c) $\eta_{dual} > \eta_{diesel} > \eta_{otto}$
(d) $\eta_{otto} > \eta_{dual} > \eta_{diesel}$

Q32. Match List-I with List-II and select the correct answer using the codes given below the lists: [IES-2001]

List-I (Cycles operating between fixed temperature limits)	List-II (Characteristic of cycle efficiency η)
A. Otto cycle	**1. η depends only upon temperature limits**
B. Diesel cycle	**2. η depends only on pressure limits**
C. Carnot cycle	**3. η depends on volume compression ratio**
D. Brayton cycle	**4. η depends on cut-off ratio and volume compression ratio**

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

Q33. 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. Air standard efficiency of Otto cycle	**1. Mechanical efficiency**
B. Morse test	**2. Diesel cycle**
C. Constant volume cycle	**3. Brake thermal efficiency**
D. Constant pressure heat addition	**4. Otto cycle**
	5. $1-\dfrac{1}{r^{(\gamma-1)}}$

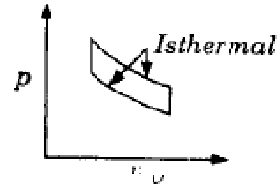
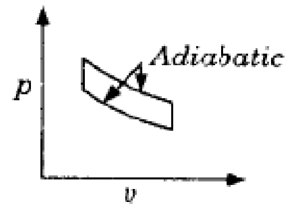
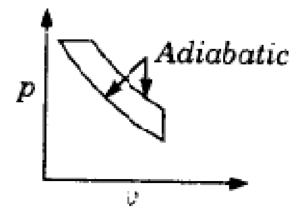
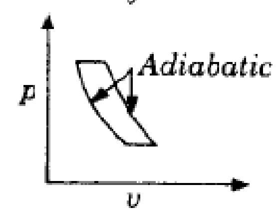
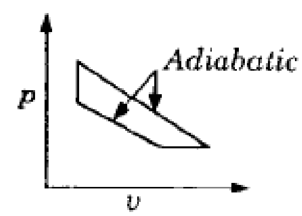
Codes:

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

Q34. Assertion (A): The C.I. engine is found to be more efficient than an S.I. engine.
Reason (R): Modern C.I. engines operate on a dual-cycle, which has efficiency greater than the Otto cycle. **[IES-2001]**
(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

Q35. Match List-I (name of cycles) with List-II (pv diagrams) and select the correct answer using the codes given below the lists: [IES-1999]

List I **List II**

A. Stirling cycle	1.	
B. Diesel cycle	2.	
C. Otto cycle	3.	
D. Atkinson cycle	4.	
	5.	

Code:

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

Q36. Match List-I (details of the processes of the cycle) with List-II (name of the cycle) and select correct answer using the codes given below the Lists:

List-I	List-II	[IES-1997]
A. Two isothermals and two adiabatic	**1. Otto**	
B. Two isothermals and two constant volumes	**2. Joule**	
C. Two adiabatic and two constant volumes	**3. Carnot**	
D. Two adiabatic and two constant pressures	**4. Stirling**	

Code:

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

Q37. Assertion (A): In practice, the efficiency of diesel engines is higher than that of petrol engines. **[IES-1997]**

Reason (R): For the same compression ratio, the efficiency of diesel cycle is higher than that of Otto cycle.

(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

Q38. For constant maximum pressure and heat input, the air standard efficiency of gas power cycles is in the order [IES-1993]
(a) Diesel cycle, dual cycle, Otto cycle
(b) Otto cycle, Diesel cycle, dual cycle
(c) Dual cycle, Otto cycle, Diesel cycle
(d) Diesel. cycle, Otto cycle, dual cycle

Q39. For the same maximum pressure and temperature [IES-1992]
(a) Otto cycle is more efficient than diesel cycle
(b) Diesel cycle is more efficient than Otto cycle
(c) Dual cycle is more efficient than Otto and diesel cycles
(d) Dual cycle is less efficient than Otto diesel cycles

Q40. Match List I (Cycles) with List II (Processes) and select the correct answer using the codes given below the Lists: [IES-2003]

List I (Cycles)	List II (Processes)
A. Bell Coleman cycle	**1. One constant pressure, one constant volume and two is entropic**
B. Stirling cycle	**2. Two constant pressure and two is entropic**
C. Ericsson cycle	**3. Two constant pressure and two isothermal**
D. Diesel cycle	**4. Two constant volume and two isothermal**

Codes:

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

Q41. Match List-l (Gas Cycles) with List-ll (Thermodynamic co-ordinates) and select the correct answer using the codes given below the lists: [IES-2009]

List-I	List-II
A. Carnot cycle	**1. Pressure-Entropy**
B. Brayton cycle	**2. Pressure-Temperature**
C. Ericsson cycle	**3. Temperature-Volume**
D. Stirling cycle	**4. Temperature-Entropy**

Codes:

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

Previous Years IAS Questions

Carnot cycle

Q1. Assertion (A): Two engines A and B work on the Carnot cycle. Engine A uses air as the working substance and B uses steam as the working substance. Both engines are having same efficiency. **[IAS-2007]**
Reason (R): Carnot cycle efficiency is independent of working substance.
(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

Q2. A heat engine working on Carnot cycle receives heat at the rate of 40 kW from a source at 1200 K and rejects it to a sink at 300 K. The heat rejected is
(a) 30 kW (b) 20 kW (c) 10 kW (d) 5 kW **[IAS-2001]**

Q3. A heat engine using lake water at 12°C as source and the surrounding atmosphere at 2°C as sink executes 1080 cycles per min. If amount of heat supplied per cycle is 57 J, what is the output of the engine? **[IAS-2004]**
(a) 66 W (b) 56 W (c) 46 W (d) 36 W

Stirling cycle

Q4. Which one of the following pairs of air standard cycles has the same efficiency as that of Carnot cycle when operating between the same maximum (source) and minimum (sink) temperatures together with ideal regeneration?
(a) Otto and Brayton (b) Brayton and Ericsson
(c) Ericsson and Stirling (d) Stirling and Otto **[IAS-1997]**

Ericsson cycle

Q5. A gas turbine cycle with infinitely large number of stages during compression and expansion approaches **[IAS-2003]**
(a) Stirling cycle (b) Atkinson cycle
(c) Ericsson cycle (d) Brayton cycle

Lenoir cycle

Q6. Pulse jet engine operation can be idealized/ approximated to follow which one of the following? **[IAS-2007]**
(a) Brayton cycle (b) Ericsson cycle
(c) Lenoir cycle (d) Stirling cycle

The diesel cycle

Q7. In the case of a Diesel cycle, increasing the cut-off ratio will increase
(a) Efficiency (b) mean effective pressure **[IAS-1996]**
(c) The maximum weight (d) the engine weight

Comparison of Otto, diesel, and dual (limited-pressure) cycles

Q8. Match List - I (Thermodynamic system/prime mover) with List - II (Thermodynamic Cycle) and select the correct answer using the codes given below the list: **[IAS-1998]**

List – I	List - II
A. Air liquefaction plant	1. Atkinson cycle
B. Gas turbine with multistage compression and multistage expansion	2. Brayton cycle
C. Free piston engine/compressor with a gas turbine	3. Ericsson cycle
D. Pulse jet	4. Reversed striling cycle
	5. Lenoir cycle

Codes:

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

Q9. **Assertion (A):** For a given compression ratio, the thermal efficiency of the Diesel cycle will be higher than that of the Otto cycle. **[IAS-2000]**
Reason(R): In the Diesel cycle, work is also delivered during heat addition.
(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

Q10. **Match List I (Cycle) with List II (Process) and select the correct answer:** **[IAS-2000]**

List I	List II
A. Otto	**1. Two isothermal and two constant volumes**
B. Stirling	**2. Two isothermal and two isobars**
C. Ericsson	**3 Two isentropic and two isobar**
D. Brayton	**4.Two isentropic and two constant volume**
	5. Two isentropic and two isothermal

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

Q11. **The air standard efficiency of diesel cycle will be less than that of Otto cycle in the case of** **[IAS-1999]**
(a) Same compression ratio and same heat input
(b) Same maximum pressure and same heat input
(c) Same maximum pressure and same output
(d) Same maximum pressure and S8.me maximum temperature

Q12. **Which one of the following cycles working within the same temperature limits has the highest work ratio?** **[IAS-1998]**
(a) Carnot cycle (b) Joule cycle
(c) Otto cycle (d) Rankine cycle

Q13. **Match List I with List II and select the correct answer using the codes given below the lists:** **[IAS-1996]**

List I	List II
A. Compression ratio	**1. Brayton cycle**
B. Pressure ratio	**2. Diesel cycle**
C. Cut-off ratio	**3. Dual combustion cycle**
D. Explosion ratio	**4. Otto cycle**

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

Q14. **A Diesel and Otto cycle have the same compression ratio 'r'. The cut-off ratio of the cycle is's'. The air standard efficiency of these cycles will be equal when** **[IAS-1996]**
(a) $s^k - k(s-1) - 1 = 0$ (b) $s^k - k(s-1) + 1 = 0$
(c) $s^k - k(s-1) + 1 = 0$ (d) $s^k - (s-1) - k = 0$

Q15. **For the same compression ratio and the same heat input, the correct sequence of the increasing order of the thermal efficiencies of the given cycles is** **[IAS-1996]**
(a) Otto, Diesel, dual (b) Diesel, dual Otto
(c) Dual, Diesel, Otto (d) Dual, Otto, Diesel

Q16. **Match List I with List II and select the correct answer using the codes given below the lists:** **[IAS-1995]**
List-I **List-II**

A. Twoconstant volumes and two adiabatics					**1. Ericsson**			
B. Twoconstant pressures and two adiabatics					**2. Stirling**			
C.Twoconstant volumes and two isothermals					**3. Joule**			
D. Twoconstant pressure and two isothermals					**4. Otto**			

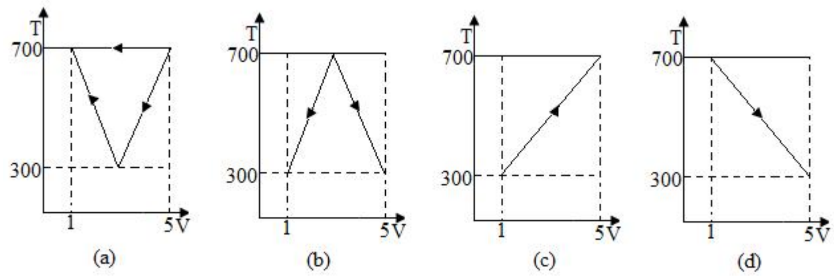
Codes:

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

Q17. Otto cycle efficiency is higher than Diesel cycle efficiency for the same compression ratio and heat input because, in Otto cycle **[IAS 1994]**

(a) Combustion is at constant volume
(b) Expansion and compression are isentropic
(c) Maximum temperature is higher
(d) Heat rejection is lower

Q18. Which one of the following hypothetical heat engine cycle represents maximum efficiency? **[IAS-1999]**



ANSWER WITH EXPLANATION

Previous Years GATE Answers

1. Ans. (a) $\eta = \frac{W}{Q_1}$ or $0.75 = \frac{50}{Q_1}$ or $Q_1 = 66.67\,kJ$

And $W = Q_1 - Q_2$ or $Q_2 = 66.67 - 50 = 16\,2/3\,kJ$

2. Ans. (b) $\eta_{cannot} = 1 - \frac{T_{min}}{T_{max}}$ or $0.75 = 1 - \frac{T_{min}}{(273+727)}$ $\therefore T_{min} = 250K = -23^0C$

3. Ans. (d)

4. Ans. (c) $\eta = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{70}{80} = 12.5\%$

5. Ans. (c) Note:

(i) Since part of the heat is transfers at constant volume process, the efficiency of the Stirling cycle is less than that of the Carnot cycle.

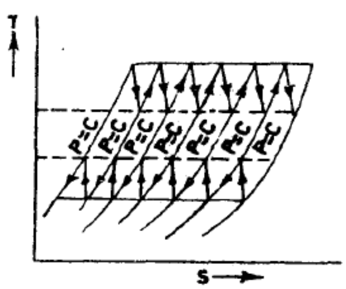
(ii) The regenerative Stirling cycle has the same efficiency as that of Carnot cycle

(iii) Efficiency of Stirling cycle without regeneration

$$\eta = 1 - \frac{\left(\frac{T_1}{T_2} - 1\right) + (\gamma - 1)\ln r}{\left(\frac{T_1}{T_2} - 1\right) + (\gamma - 1)\frac{T_1}{T_2}\ln r}$$

6 Ans. (d)

7. Ans. (c) Brayton cycle with many stages of intercooling and reheating approximates to Ericsson cycle.



8. Ans. (b) Intake process isn't constant volume heat rejection processes. it is constant pressure process.

9. Ans. (d)

Initial volume (v_1)

$= \frac{\pi d^2}{4} \times L = \frac{\pi \times (0.1)^2}{4} \times 0.15 m^3 = 1.1781 \times 10^{-3} m^3$

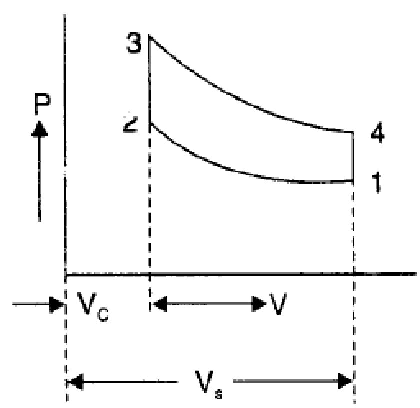
Final Volume (v_2)

$= 196.3$ cc $= 0.1963 \times 10^{-3}$ m^3 $= v_c$

$\therefore$ Compression ratio $= \frac{v_1 + v_c}{v_c} = 7$

$\therefore \eta = 1 - \frac{1}{r_c^{\gamma-1}} = 1 - \frac{1}{7^{1.4-1}} = 0.5408$

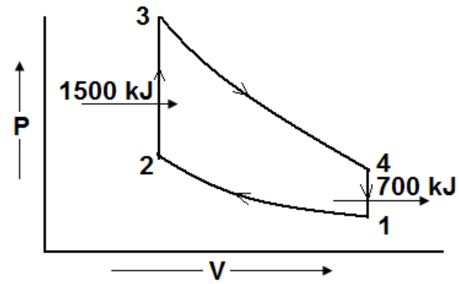
$W = \eta Q = 0.5408 \times 1800 = 973.5 kJ$



10. Ans. (d) compression ratio $(r_c) = 11$ $\therefore \eta = 1 - \frac{1}{r_c^{\gamma-1}} = 1 - \frac{1}{(11)^{1.4-1}} = 0.615$

11. Ans. (a) $\%\eta = \left(1-\frac{1}{r_c^{\gamma-1}}\right)\times 100\% = \left(1-\frac{1}{8.5^{(1.4-1)}}\right)\times 100 = 57.5\%$

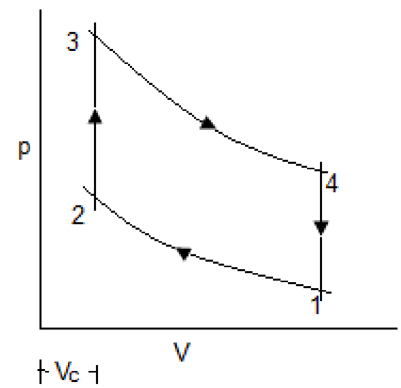
12. Ans.(d)



$$\text{mep} = \frac{\text{area of } p-v \text{ diagram}}{\text{length of } p-v \text{ diagram}}$$
$$= \frac{\textit{work done}}{\Delta V}$$
$$= \frac{Q_1 - Q_2}{(V_1 - V_2)}$$
$$= \frac{(1500-700)\text{KJ}}{(0.861-0.0861)\text{m}^3/\text{kg}}$$
$$= 1032 \text{ KPa}$$

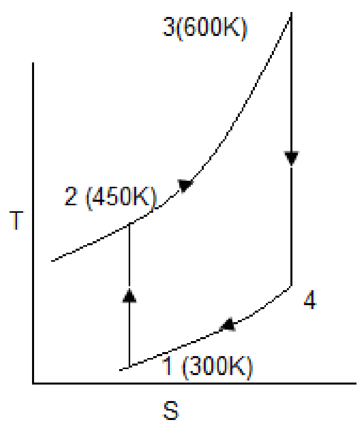
$$r = 10 = \frac{V_1}{V_2}$$
$$P_1V_1 = RT_1$$
$$V_1 = \frac{0.287\times(300)}{100} = 0.861\,\text{m}^3/\text{kg}$$
$$V_2 = 0.0861$$

13. Ans. (b) $r_c = \frac{V_1}{V_2} = \frac{V_1}{V_c}$ or $V_1 = r_c \times V_c = 5.5V_c$

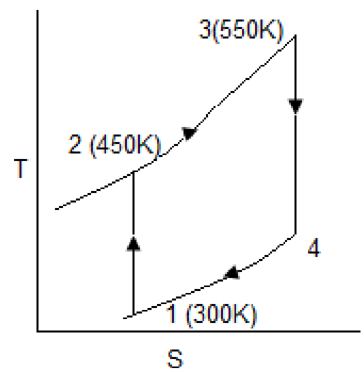


$$p_m = \frac{\text{Work per cycle}}{\text{Piston displacement volume}}$$
$$= \frac{23.625\times10^5\times V_c}{(V_1 - V_2)}\text{N/m}^2$$
$$= \frac{23.625\times10^5\times V_c}{(5.5V_c - V_c)}\text{ Pa} = 5.25\text{bar}$$

14. Ans. (a)
15. Ans. (b)



Otto cycle



Brayton cycle

$$\eta_{\text{Otto}} = \eta_o = 1-\frac{1}{r_c^{\gamma-1}} = 1-\left(\frac{v_2}{v_1}\right)^{\gamma-1} = 1-\frac{T_1}{T_2} = 1-\frac{300}{450} = 0.33$$

$$\eta_{\text{Brayton}} = \eta_B = 1-\frac{1}{r_p^{\frac{\gamma-1}{\gamma}}} = 1-\frac{1}{r_c^{\gamma-1}} = 1-\left(\frac{v_2}{v_1}\right)^{\gamma-1} = 1-\frac{T_1}{T_2} = 1-\frac{300}{450} = 0.33$$

16. Ans. (a)

$$\text{Otto} \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \frac{T_2}{T_1} = \frac{T_4}{T_3} \text{ or } T_4 = T_3 \times \frac{T_2}{T_1} = 600 \times \frac{450}{300} = 900\text{K}$$

$$\text{Brayton} \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \frac{T_2}{T_1} = \frac{T_4}{T_3} \text{ or } T_4 = T_3 \times \frac{T_2}{T_1} = 550 \times \frac{450}{300} = 825\text{K}$$

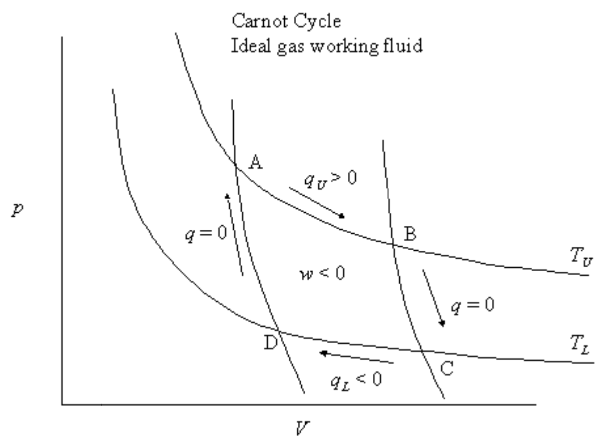
$$W_{Otto} = c_p\left(T_3 - T_4\right)_o \quad \text{and} \quad W_{Brayton} = c_p\left(T_3 - T_4\right)_B$$

$$\text{So } W_{Otto} > W_{Brayton}$$

17. Ans. (c)
18. Ans. (a, d)

Previous Years IES Answers

1. Ans. (b)



2. Ans. (d) We know that

$$\eta = 1 - \frac{T_2}{T_1}$$

Since Efficiency of the Engine purely depends upon source and sink temperatures and independent of the working substances. All the engines have same efficiency

3. Ans. (d) Don't confuse with Diesel cycle. As stirling cycle's efficiency is equal to Carnot cycle.

4. Ans. (a)

5. Ans. (d)

6. Ans. (b) $\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{v_1}{v_2}\right)^{\gamma-1}$ Given $\frac{v_2}{v_1}$ =32 or $\frac{T_2}{T_1} = \left(\frac{1}{32}\right)^{1.4-1} = \frac{1}{4}$

$\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$ or $Q_2 = Q_1 \text{x} \frac{T_2}{T_1}$ =52x$\frac{1}{4}$ = 13 kJ

7. Ans. (a) Least rate of heat rejection per kW net output $= \frac{Q_2}{w}$ it will occur when reversible process will occur.

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2} = \frac{Q_1 - Q_2}{T_1 - T_2} = \frac{W}{T_1 - T_2} \quad \text{or} \quad \frac{Q_2}{W} = \frac{T_2}{T_1 - T_2} = \frac{293}{879 - 293} = 0.5$$

8. Ans. (c) For maximum improvement in efficiency source temperature should be raised and sink temperature lowered.

9. Ans. (d) Here T_1 = 273 + 12 = 285°K

Heat drawn per cycle = 57J and no. of cycles per m = 1080 i.e. 1080/60 = 18 cycles/sec.

$$\eta = \frac{T - T_2}{T_1} = \frac{285 - 275}{285} = \frac{\text{Work done}}{\text{Heat input}} = \frac{\text{Work done}}{57}$$

work done per cycle $= \frac{10 \times 57}{285}$ J and work done per sec = $\frac{570}{285} \times 18\,\text{J/s} = 36\,\text{W}$

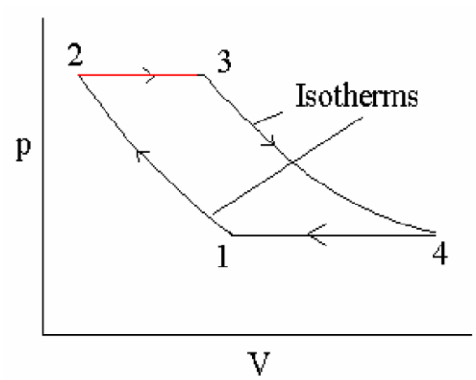
10. Ans. (b)

11. Ans. (a) 1-2 and 3-4 are isothermal process

2-3 and 4-1 may be isobaric or isochoric process

So this cycle may be Starling cycle of Ericsson cycle but steepness of the curve 2-3 and 1-4 is very high. Therefore we may say it is Starling cycle.

12. Ans. (c)



13. Ans. (c)

14. Ans. (b)

15. Ans. (a)

16. Ans. (c) Otto cycle involves two isentropic and two constant volume processes.

17. Ans. (c)

18. Ans. (d)

19. Ans. (d)

20. Ans. (a)

21. Ans. (b)

22. Ans. (d)

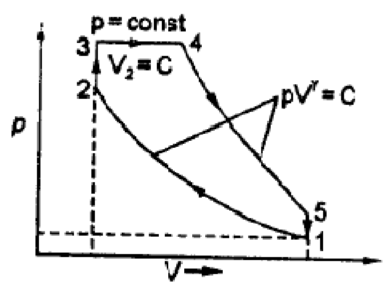
23. Ans. (a) 2 is false, the voltage for spark is in the order of 25 KV

3 is false, best material platinum but mostly used nickel alloy.

24. Ans. (c)

25. Ans. (a)

26. Ans. (a)



27. Ans. (b)

28. Ans. (b)

29. Ans. (a)

30. Ans. (d)

31. Ans. (d)

32. Ans. (a)

33. Ans. (a)

34. Ans. (b)

35. Ans. (b)

36. Ans. (c)
37. Ans. (c)
38. Ans. (a)
39. Ans. (b)

Following figures shows cycles with same maximum pressure and same maximum temperature. In this case, Otto cycle has to be limited to lower compression ratio to fulfil the condition that point 3 is to be a common state for both cycles. T-*s* diagram shows that both cycles will reject the same amount of heat.

$$\text{Thermal efficiency} = 1 - \frac{Q_p}{Q_{supplied}} = 1 - \frac{\text{Constant}}{Q_{supplied}}$$

Thus the cycle with greater heat addition $Q_{supplied}$ is more efficient.

$$\therefore \quad \eta_{Diesel} > \eta_{Dual} > \eta_{Otto}$$

40. Ans. (c)
41. Ans. (c)

Previous Years IAS Answers

1. Ans. (d) efficiency of cannot cycle (η) $=1-\frac{T_2}{T_1}$ it only depends on reservoirs temperature nothing else.

2. Ans. (c) $\frac{Q_1}{T_1} = \frac{Q_2}{T_2} \qquad or\, Q_2 = \frac{Q_1}{T_1} \times T_2 = \frac{40}{1200} \times 300 = 10kW$

3. Ans. (d) $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{275}{285} = 0.0351$

$$Output = \eta, Q = 0.0351 \times 573 / cycle = 1.2J / cycle = 2 \times \frac{1080}{60} = 36W$$

4. Ans. (c)
5. Ans. (c)
6. Ans. (c)
7. Ans. (b)
8. Ans. (c)
9. Ans. (d) For same compression ratio Otto cycle has maximum efficiency.
10. Ans. (a)
11. Ans. (a)
12. Ans. (d) W_c is pump work in liquid state i.e. minimum
13. Ans. (c)
14. Ans. (a)

$$\eta_{otto} = 1 - \frac{1}{r^{k-1}} = \eta_{diest} = 1 - \frac{\left(S^k - 1\right)}{k\left(S-1\right)r^{k-1}}$$

$$\text{or} \quad S^k - 1 = k\left(s-1\right) \qquad \text{or} \quad S^k - k\left(s-1\right) - 1 = 0$$

15. Ans. (b)
16. Ans. (d)
17. Ans. (d) For same heat input and same compression ratio, in case of Otto cycle, efficiency in higher because the heat rejection is lower.
18. Ans. (b)

$$\text{Work done by all cases is same} = \frac{1}{2}\times(5-1)\times(700-300) = 800\,\text{units}$$

$$\text{Heat input for (a) and (c) is same} = 700\times(5-1) = 280\,\text{units}$$

$$\text{Heat input for (b) is} \left\{300\times\left(\frac{5-1}{2}\right)+\frac{1}{2}\times\left(\frac{5-1}{2}\right)(700-300)\right\} = 1000\,\text{units}$$

$$\text{Heat input for (d) is} \left\{300\times(5-1)+\frac{1}{2}\times(5-1)\times(700-300)\right\} = 2000\text{units}$$

$$\therefore \text{max imum}\,\eta\,\text{when min imum heat input is case (b)}$$

2. SI and CI Engines

OBJECTIVE QUESTIONS (GATE & IES)

Previous Years GATE Questions

Ignition limits

Q1. A fuel represented by the formula C_8H_{16} is used in an I.E. Engine. Given that the molecular weight of air is 29 and that 4.76 kmols of air contain 1 kmol of oxygen and 3.76 kmol of nitrogen, the Air /Fuel ratio by mass is [GATE-2000]
(a) 11.47 (b) 12.78 (c) 14.79 (d) 19.52

Q2. For a spark ignition engine, the equivalence ratio (ϕ) of mixture entering the combustion chamber has values [GATE-2003]
(a) ϕ < 1 for idling and ϕ > 1 for peak power conditions
(b) ϕ > 1 for both idling and peak power conditions
(c) ϕ > 1 for idling and ϕ < 1 for peak power conditions
(d) ϕ < 1 for both idling and peak power conditions

Combustion in SI engine

Q3. Knocking tendency in a S.l. engine reduces with increasing [GATE-1993]
(a) Compression ratio (b) wall temperature
(c) Supercharging (d) engine speed

Diesel knock

Q4. An IC engine has a bore and stroke of 2 units each. The area to calculate heat loss can be taken as [GATE-1998]
$(a) 4\pi$ $(b) 5\pi$ $(c)\ 6\pi$ $(d)\ 8\pi$

Previous Years IES Questions

Ignition limits

Q1. For a conventional S.I. engine, what is the value of fuel-air ratio in the normal operating range?
(a) 0.056 – 0.083 (b) 0.083 – 0.56
(c) 0.0056 – 0.83 (d) 0.056 – 0.83 **[IES 2007]**

Q2. The stoichiometric air/fuel ratio for petrol is 15: 1. [IES-2004]
What is the air/fuel ratio required for maximum power?
(a) 16 : 1 - 18 : 1 (b) 15 : 1 (c) 12 : 1 - 18 : 1 (d) 9: 1 - 11 : 1

Q3. The air fuel ratio for idling speed of an automobile patrol engine is closer to
(a) 10: 1 (b)15:1 (c) 17 : 1 (c) 21: 1 **[IES-1992]**

Q4. **Match List I with List II and select the correct answer using the given code given below the lists:** **[IES 2007]**

List I (SI Engine Operational mode)	**List I (A/F Ratio Supplied by the Carburetor)**
A. Idling	**1. 3**
B. Cruising	**2. 10**
C. Maximum Power	**3. 13**
D. Cold starting	**4. 16**
	5. 20

Codes:

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

Q5. **Match List I (S.I. Engine Operational Mode) with List II (Air fuel Ratio by Mass) and select the correct answer:** **[IES-2004]**

List I	**List II**
A. Idling	**1. 4: 1**
B. Cruising	**2. 10: 1**
C. Maximum power	**3. 12.5: 1**
D. Cold starting	**4. 16: 1**
	5. 14.8: 1

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

Q6. **The air fuel ration for idling speed of an automobile patrol engine is closer to**
(a) 10: 1 (b)15:1 (c) 17 : 1 (c) 21: 1 **[IES-1992]**

Q7. **Match List I with List II and select the correct answer** **[IES-1996]**

List I (SI engine operating mode)	**List II (Desired air-fuel ratio)**
A. Idling	**1. 13.0**
B. Cold starting	**2. 4.0.**
C. Cruising	**3. 16.0**
D. Full throttle	**4. 9.0**

Codes:

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

Q8. **Match List I (Air-fuel ratio by mass) with List II (Engine operation mode) and select the correct answer using the codes given below the Lists** **[IES-2000]**

List I	**List II**
A. 10: 1	**1. CI engine part load**
B. 16: 1	**2. SI engine part load**
C. 35: 1	**3. SI engine idling**
D. 12.5: 1	**4. CI full load**
	5. SI full load

Codes:

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

Q9. **Match List I with List II and select the correct answer using the codes given below the lists:**

List I (Operating mode of SI engine)	**List II (Appropriate Air-Fuel ratio)**
A. Idling	**1. 12.5** **[IES-1995]**
B. Cold starting	

C. Cruising					**3. 16.0**			
D. Maximum power					**4. 22.0**			
					5. 3.0			
Codes: A	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a) 2	4	5	1	(b)	1	3	4	2
(c) 5	2	1	3	(d)	2	5	3	1

Q10. Match List I (S.I. Engine Operating Mode) with List II (Approximate A/F Ratio) and select the correct answer using the code given below the Lists:

List I **List II** **[IES-2005]**

List I	**List II**
A Cold Start	**1. 10: 1**
B. Idling	**2. 16:1**
C. Cruising	**3. 13 : 1**
D. Maximum Power	**4. 4 : 1**
	5. 20: 1

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

Q11. Match List I with List II and select the correct answer. **[IES-1994]**

List I (Operating condition)	**List II (Approximate air fuel ratio)**
A. Idling	**1. 16**
B. Part load operation	**2. 10**
C. Full load	**3. 12.5**
D. Cold start	**4. 3**

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

Q12. If methane undergoes combustion with the stoichiometric quantity of air, the air-fuel ratio on molar basis would be: **[IES-1997]**
(a) 15.22: 1 (b) 12.30: 1 (c) 14.56: 1 (d) 9.52: 1

Q13. Stoichiometric air-fuel ratio by volume for combustion of methane in air is:
(a) 15: 1 (b)17.16: 1 (c) 9.52: 1 (d) 10.58: 1 **[IES-2002]**

Q14. Auto -ignition time for petrol- air mixture is minimum when the ratio of actual fuel-air ratio and chemically correct fuel air ratio is **[IES-2002]**
(a) 0.8 (b) 1.0 (c) 1.2 (d) 1.5

Combustion in SI engine

Q15. Velocity of flame propagation in the SI engine is maximum for a fuel-air mixture which is **[IES-1999]**
(a) 10% richer than stoichiometric
(b) Equal to stoichiometric
(c) More than 10% richer than stoichiometric
(d) 10% leaner than stoichiometric

Q16. Assertion (A): In SI engines, as the engine speed increases, spark is required to be advanced.
Reason (R): As the engine speed increases, flame velocity increases. **[IES-1996]**
(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

Q17. Which of the following cannot be caused by a hot spark plug? [IES-2005]
1. Pre-ignition 2. Post-ignition 3. Detonation 4. Run-on-ignition
Select the correct answer using the code given below:
(a) 1 and 4 (b) 2 only (c) 2 and 3 (d) 3 only

Q18. By higher octane number of SI fuel, it is meant that the fuel has [IES-1995]
(a) Higher heating value (b) higher flash point
(c) Lower volatility (d) longer ignition delay

Q19. Match List I with List IT and select the correct answer using the codes given below the lists: [IES-1993]

List I (S.l. Engine problem)	List II (Characteristic of fuel responsible for the problem)
A. Cold starting	1. Front end volatility
B. Carburetor icing	2. Mid-range volatility
C. Crankcase dilution	3. Tail end volatility

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

Q20. List I gives the different terms related to combustion while List II gives the outcome of the events that follow. Match List I with List II and select the correct answer. [IES-1996]

List I	List II
A. Association	1. Pseudo shock
B. Dissociation	2. Knock
C. Flame front	3. Endothermic
D. Abnormal combustion	4. Exothermic

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

Detonation or knocking

Q21. Which of the following factors increase detonation in the SI engine?
1. Increased spark advance. [IES-1993]
2. Increased speed.
3. Increased air-fuel ratio beyond stoichiometric strength
4. Increased compression ratio.
Select the correct answer using the codes given below:
(a) 1 and 3 (b) 2 and 4 (c) 1, 2 and 4 (d) 1 and 4

Q22. Consider the following statements: [IES-2006]
1. In the SI engines detonation occurs near the end of combustion whereas in CI engines knocking occurs near the beginning of combustion.
2. In SI engines no problems are encountered on account of pre-ignition.
3. Low inlet pressure and temperature reduce knocking tendency in SI engines but increase the knocking tendency in CI engines.
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

Q23. The tendency of petrol to detonate in terms of octane number is determined by comparison of fuel with which of the following? [IES-2006]
(a) Iso-octane (b) Mixture of normal heptane and iso-octane
(c) Alpha methyl naphthalene (d) Mixture of methane and ethane

Q24. Consider the following statements: [IES-2006]
In order to prevent detonation in a spark-ignition engine, the charge away from the spark plug should have
1. Low temperature 2. Low density 3. Long ignition delay
Which of the statements given above is/are correct?
(a) Only 1 (b) Only 2 (c) Only 3 (d) 1, 2 and 3

Q25. For minimizing knocking tendency is SI engine, where should the space plug be located? [IES-2008]
(a) Near inlet valve
(b) Away from both the valves
(c) Near exhaust valve
(d) Midway between inlet and exhaust valves

Q26. Which of the following action(s) increaser(s) the knocking tendency in the S I. engine?
(a) Increasing mixture strength beyond equivalence ratio (ϕ) =14 **[IES-2004]**
(b) Retarding the spark and increasing the compression ratio
(c) Increasing the compression ratio and reducing engine speed
(d) Increasing both mixture strength beyond equivalence ratio (ϕ)= 14 and the compression ratio

Q27. In spark ignition engines knocking can be reduced by: [IES-2002]
(a) Increasing the compression ratio
(b) Increasing the cooling water temperature
(c) Retarding the spark advance
(d) Increasing the inlet air temperature

Q28. In a SI engine, combustion stage I takes 1 ms and combustion stage II takes 1·5 ms when the engine runs at 1000 rpm. If stage I time duration is independent of engine speed what will be the additional spark advance necessary when the engine speed is doubled? [IES-2008]
(a) 0° (b) 6° (c) 12° (d) 24°

Q29. Which of the following are the assumptions involved in the auto-ignition theory put forth for the onset of knock in SI engines? [IES-1998]
1. Flame velocity is normal before the onset of auto ignition.
2. A number of end-gas elements auto ignite simultaneously.
3. **Preflame reactions are responsible for preparing the end-gas to ignite.**
Select the correct answer using the codes given below:
(a) 1 and 2 (b) 1 and 3 (c) 2 and 3 (d) 1, 2 and 3

Q30. Consider the following statements: [IES-1996]
Knock in the SI engine can be reduced by
1. Supercharging
2. Retarding the spark.
3. Using a fuel of long straight chain structure
4. Increasing the engine speed.
Of these correct statements are
(a) 1 and 2 (b) 2 and 3 (c) 1, 3 and 4 (d) 2 and 4

Q31. Assertion (A): Self-ignition temperature of the end charge must be higher to prevent knocking of an SI engine. **[IES-1994]**
Reason (R): Higher compression ration increases the temperature of the air-fuel mixture.

(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

Q32. Match List I with List II, in respect of SI engines, and select the correct answer by using the codes given below the lists: [IES-1995]

List I	List II
A. Highest useful compression ratio	**1. Ignitable mixture**
B. Dopes	**2. Knock rating of fuels**
C. Limiting mixture strength	**3. Detonation**
D. Delay period	**4. Chain of chemical reactions in combustion chamber**

Codes:	**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	4	2	1

Q33. Consider the following statements: [IES-1997]
Detonation in the S.I. engine can be suppressed by
1. Retarding the spark timing.
2. Increasing the engine speed.
3. Using 10% rich mixture.
Of these statements
(a) 1 and 3 are correct
(b) 2 and 3 are correct
(c) 1, 2 and 3 are correct
(d) 1 and 2 are correct

Q34. Consider the following statements [IES-2000]
1. **Octane rating of gasoline is based on iso-octane and iso-heptane fuels which are paraffin**
2. **Tetraethyl lead is added to gasoline to increase octane number.**
3. **Ethylene di-bromide is added as scavenging agent to remove lead deposits on spark plugs.**
4. **Surface ignition need not necessarily cause knocking.**

Which of these statements are correct?
(a) 1, 2, 3 and 4 (b) 2, 3 and 4 (c) 1 and 4 (d) 1,2 and 3

SI engine combustion chamber designs

Q35. The volumetric efficiency of a well designed SI engine is in the range of
(a) 40% - 50%
(b) 50% - 60%
(c) 60% - 70%
(d) 70% - 90% **[IES-2002]**

Q36. Consider the following statements relevant to the ignition system of SI engine:
1. **Too small a dwell angle will lead to the burning of condenser and contact points.**
2. **Too small a dwell angle will result in misfiring. [IES-2002]**
3. **Too large a dwell angle will result in burning of condenser and contact points.**
4. **Too large a dwell angle will result in misfiring.**

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

Q37. Knocking in the SI engine decreases in which one of the following orders of combustion chamber designs? [IES-1995]
(a) F head, L head, I head
(b) T head, L head, F head.

(c) I head, T head, F head (d) F head, I head, T head.

Q38. Which of the following feature(s) is/are used in the combustion chamber design to reduce S.I engine knock? [IES-2004]
(a) Spark plug located away from exhaust value, wedge shaped combustion chamber and short flame travel distance
(b) Wedge shaped combustion chamber
(c) Wedge shaped combustion chamber and short flame travel distance
(d) Spark plug located away from exhaust value, short flame travel distance and side value design

Q39. Which of the following combustion chamber design features reduce(s) knocking in S.I. engines? [IES-2005]
1. Spark plug located near the inlet valve. 2. T-head.
3. Wedge shaped combustion chamber 4. Short flame travel distance.
Select the correct answer using the code given below:
(a) 1 and 3 (b) 3 only (c) 3 and 4 (d) 1 and 2

Q40. A two-stroke engine has a speed of 750 rpm. A four-stroke engine having an identical cylinder size runs at 1500 rpm. The theoretical output of the two-stroke engine will
(a) Be twice that of the four-stroke engine
(b) Be half that of the four-stroke engine
(c) Be the same as that of the four-stroke **[IES-1997]**
(d) Depend upon whether it is a C.I. or S.I. engine

Q41. For same power output and same compression ratio, as compared to two-stroke engines, four-stroke S.I. engines have: [IES-1997]

(a) Higher fuel consumption (b) lower thermal efficiency
(c) Higher exhaust temperatures (d) higher thermal efficiency

Q42. Match List I with List 11and select the correct answer using the codes given below the lists:

List I	List II [IES-1993]
A. Pre-combustion chamber	**1. Compression swirl**
B. Turbulent chamber	**2. Masked inlet valve**
C. Open combustion chamber	**3. Spark ignition**
D. F-head combustion chamber	**4. Combustion induced swirl**
	5. M-chamber

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

Q43. If the approximate average mean pressures during induction, compression, power and exhaust strokes of an internal combustion engine are respectively 15 kN/m² below atmosphere, 200 kN/m² above atmosphere, 1000 kN/m² above atmosphere and 20 kN/m² above atmosphere, then the resultant mean effective pressure, in kN/m², is [IES-1994]
(a) 765 (b) 795 (c) 800 (d) 805

Combustion in the CI engine

Q44. The delay period in CI engine depends upon which of the following?
(a) Temperature and pressure in the cylinder at the time of injection
(b) Nature of the fuel mixture strength

(c) Relative velocity between the fuel injection and air turbulence pressure of residual gases
(d) All of the above **[IES 2007]**

Diesel knock

Q45. Which of the following statements is "true"? [IES-1992]
(a) The term "KNOCK" is used for on identical phenomenon in a spark ignition and compression ignition engine
(b) "KNOCK" is a term associated with a phenomenon taking place in the early part of combustion in a spark ignition engine and the later part of combustion in a spark ignition engine
(c) "KNOCK" is a term associated with a phenomenon taking place in the early part of combustion in a spark ignition engine and the later part of combustion in a compression ignition engine
(d) None of the above

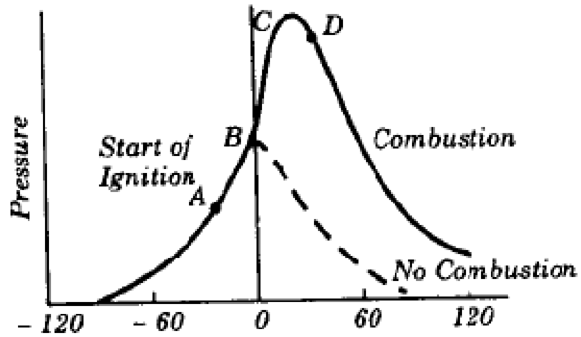
Q46. The knocking tendency in compression ignition engines increases with:
(a) Increase of coolant water temperature (b) Increase of temperature of inlet air
(c) Decrease of compression ratio (d) Increase of compression ratio **[IES-2005]**

Q47. Assertion (A): A very high compression ratio is favoured for a CI engine, in order to attain high mechanical efficiency without knocking. **[IES-1996]**
Reason (R): The delay period in CI combustion affects rate of pressure rise and hence knocking.
(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

Q48. Which of the following factors would increase the probability of knock in the CI engines?
1. Long ignition delay of fuel
2. High self ignition temperature of fuel
3. Low volatility of fuel [IES-1995]
Select the correct answer using the codes given below:
(a) 1, 2 and 3 (b) 1 and 2 (c) 1 and 3 (d) 2 and 3.

Q49. Consider the following measures: [IES-1994]
1. Increasing the compression ratio
2. Increasing the intake air temperature.
3. Increasing the length to diameter ratio of the cylinder.
4. Increasing the engine speed.
The measures necessary to reduce the tendency to knock in CI engines would include
(a) 1, 2 and 3 (b) 1, 2 and 4 (c) 1, 3 and 4 (d) 2, 3 and 4

Q50. Hypothetical pressure diagram for a compression ignition engine is shown in the given figure. The diesel knock is generated during the period
(a) AB
(b) BC
(c) CD
(d) after D



[IES-1998]

Q51. The tendency of knocking in C I engine reduces by **[IES-2002]**
(a) High self - ignition temperature of fuel
(b) Decrease in jacket water temperature
(c) Injection of fuel just before TDC
(d) Decrease in injection pressure

Q52. Which of the following factor(s) increase(s) the tendency for knocking in the C.I. engine?
(a) Increasing both the compression ratio and the coolant temperature **[IES-2004]**
(b) Increasing both the speed and the injection advance
(c) Increasing the speed, injection advance and coolant temperature
(d) Increasing the compression ratio

Q53. Consider the following statements:
Diesel knock can be reduced by
1. Increasing the compression ratio.
2. Increasing the engine speed.
3. Increasing the injection retard.
4. Decreasing the inlet air temperature
Which of the statements given above are correct?
(a) 2 and 4 only (b) 1, 2 and 3 only
(c) 1 and 3 only (d) 1, 2, 3 and 4 **[IES 2007]**

The CI engine combustion chambers

Q54. The object of providing masked inlet valve in the air passage of compression-ignition engines is to **[IES-1994]**
(a) Enhance flow rate (b) control air flow.
(c) Induce primary swirl (d) induce secondary turbulence.

Q55. Which one of the following events would reduce the volumetric efficiency of a vertical compression - ignition engine? **[IES-1994]**
(a) Inlet valve closing after bottom dead centre.
(b) Inlet valve closing before bottom dead centre.
(c) Inlet valve opening before top dead centre.
(d) Exhaust valve closing after top dead centre.

Q56. If the performance of diesel engines of different sizes, cylinder dimensions and power ratings are to be compared, which of the following parameters can be used for such comparison? **[IES-2003]**
(a) Swept volume (b) Air fuel ratio
(c) Specific brake fuel consumption (d) Volumetric efficiency

Q57. A 4-stroke diesel engine, when running at 2000 rpm has injection duration of 1.5 ms. What is the corresponding duration of the crank angle in degrees?
(a) 18° (b) 9° (c) 36° (d) 315° **[IES-2005]**

Q58. In the operation of four-stroke diesel engines, the term 'squish' refers to the:
(a) Injection of fuel in the pre-combustion chamber **[IES-2001]**
(b) Discharge of gases from the pre-combustion chamber
(c) Entry of air into the combustion chamber
(d) Stripping of fuel from the core

Q59. Divided chamber diesel engines use lower injection pressures compared to open chamber engines because **[IES-1999]**
(a) Pintle nozzles cannot withstand high injection pressures
(b) High air swirl does not require high injection pressures for atomization
(c) High injection pressures may cause over-penetration
(d) High injection pressure causes leakage of the fuel at the pintle

Q60. For which of the following reasons, do the indirect injection diesel engines have higher specific output compared to direct injection diesel engines?
1. They have lower surface to volume ratio. **[IES-2005]**
2. They run at higher speeds.
3. They have higher air utilization factor.
4. They have lower relative heat loss.
Select the correct answer using the code given below:
(a) 1 and 2 (b) 2 only (c) 2 and 3 (d) 3 and 4

Q61. Assertion (A): Pre-chamber diesel engines use higher injection pressures when compared to open combustion chamber engines. **[IES-1997]**
Reason (R): Pre-chamber engines have higher compression pressures.
(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

Q62. Assertion (A): A pintle nozzle is employed to mix the fuel properly even with the slow air movement available with many open combustion chambers in C I engines.
Reason (R): The mixing of fuel and air is greatly affected by the nature of the air movement in the combustion chamber of C I engines. **[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

Comparison of SI and CI Engines

Q63. Which of the following pairs of engine and performance/characteristics is/are correctly matched?
1. Turbojet - Efficiency increases with flight speed
2. SI engine - Lowest specific fuel consumption
3. Turboprop - Suitable for low flight speeds
Select the correct answer using the codes given below: **[IES-1998]**
(a) 1 and 2 (b) 2 and 3 (c) 1 and 3 (d) 2 alone

Q64. Consider the following statements: **[IES-1997]**
1. Volumetric efficiency of diesel engines is higher than that of SI engines
2. When a SI engine is throttled, its mechanical efficiency decreases.

3. Specific fuel consumption increases as the power capacity of the engine increases.
4. In spite of higher compression ratios, the exhaust temperature in diesel engines is much lower than that in SI engines.
Of these statements
(a) 1, 2, 3 and 4 are correct (b) 1, 2 and 3 are correct
(c) 3 and 4 are correct (d) 1, 2 and 4 are correct

Q65. The correct sequence of the decreasing order of brake thermal efficiency of the three given basic type of IC engines is
(a) 4 stroke CI engine, 4 stroke SI engine, 2 stroke SI engine **[IES-1995]**
(b) 4 stroke SI engine, 4 stroke CI engine, 2 stroke SI engine
(c) 4 stroke CI engine, 2 stroke SI engine, 4 stroke SI engine
(d) 2 stroke SI engine, 4 stroke SI engine, 4 stroke CI engine.

Q66. Assertion (A): Specific output of a diesel engine is higher than that of the SI engine.
Reason (R): Diesel engine is built stronger and heavier with higher compression ratio.
(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 **[IES-1998]**
(d) A is false but R is true

Q67. Assertion (A): Knocking in S.I. engines is due to auto-ignition of the end charge while knocking, in C.I. engines are due to auto-ignition of the first charge.
Reason (R): Spark ignition engines employ lower compression ratio than diesel engines and the fuel used has a calorific value lower than that of diesel oil. **[IES-2001]**
(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

Q68. With reference to Turbojet and Rocket engines, consider the following statements:
1. **Efficiency of Rocket engines is higher than that of Jet engines** **[IES-2001]**
2. **Exit velocities of exhaust gases in Rocket engines are much higher than those in Jet engines**
3. **Stagnation conditions exist at the combustion chamber in Rocket engines**
4. **Rocket engines are air-breathing engines**

Which of these statements are correct?
(a) 1 and 2 (b) 1, 3 and 4 (c) 2, 3 and 4 (d) 1, 2 and 3

ANSWER WITH EXPLANATION

Previous Years GATE Answers

1 Ans. (c)

$$C_8H_{18} + 12.5\,O_2 \longrightarrow 8CO_2 + 9H_2O$$

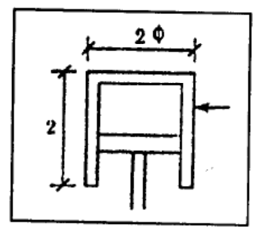
2. Ans. (b)
3. Ans. (d)
4. Ans. (c)

Explanation. Area for heat loss $= \pi d l + \left(2 \times \frac{\pi d^2}{4}\right) = \pi d l + \frac{\pi d^2}{2}$

where d = diameter, and l = length of stroke.

$\therefore$ Area of heat loss $= \pi \times 2 \times 2 + \frac{\pi \times (2)^2}{2}$

$= 6\pi.$



Previous Years IES Answers

1. Ans. (a) (A/F) for maximum power = 12 and (A/F) for Stoichiometric = 14.5
(A/F) for maximum fuel economy = 16.

2. Ans. (d) For Maximum power Air/Fuel ratio=12:1
For Maximum economy Air/Fuel ratio=16:1
For Maximum power we need rich mixture.

3. Ans. (a)
4. Ans. (c)
5. Ans. (a)
6. Ans. (a)
7. Ans. (a) Cold starting requires maximum fuel, idling requires little less fuel, full throttle requires still less fuel and idling requires minimum fuel.
8. Ans. (a)
9. Ans. (d)
10. Ans. (c)
11. Ans. (a)
12. Ans. (d)

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

i.e. Volumes of O_2 are required for 1 volume of methane

$$\therefore \text{ air fuel ratio } = \frac{2}{21} \text{ x } 100 = 9.52\%$$

13. Ans. (c)
14. Ans. (c)
15. Ans. (a) When the mixture is nearly 10% richer than stoichiometric (fuel-air ratio = 0.08 i.e. air-fuel ratio 12.5:1) the velocity of flame propagation is maximum and ignition lag of the end gas is minimum.
16. Ans. (c)
17. Ans. (b)
18. Ans. (d) A fuel with higher octane number has longer ignition delay.
19. Ans. (a)
20. Ans. (b)

21. Ans. (d) Detonation in the S.I. engines is increased by increasing spark advance and increased compression. The increased speed and lean mixtures do not have much influence.
22. Ans. (d)
23. Ans. (b)
24. Ans. (d)
25. Ans. (b)
26. Ans. (c)
27. Ans. (c)
28. Ans. (b)
29. Ans. (d)
30. Ans. (d) Knock in SI engine can be reduced by retarding spark and increasing the engine speed.
31. Ans. (d) Self ignition temperature of end of charge must be lower to prevent knocking. Higher compression ratio increases temperature of air fuel mixture. Thus A is false and R is correct.
32. Ans. (b)
33. Ans. (d) Decreasing the engine speed increases possibility of detonation
34. Ans. (b) Octane rating of gasoline is based on iso-octane and n-heptane fuels which are paraffin so 1 is wrong.
35. Ans. (d)
36. Ans. (b)
37. Ans. (c)
38. Ans. (c)
39. Ans. (c)
40. Ans. (c) In two-stroke engine there is one power stroke in 2 strokes, but in four-stroke engine there is one power stroke in 4 strokes.
41. Ans. (d) Efficiency of 4 stroke engine is higher because of better utilization compared to 2 stroke engine.
42. Ans. (a)
43. Ans. (a) Resultant mean effective pressure = 1000 - 200 - (15 + 20) = 800 - 35 = 765 kN/m^2
44. Ans. (d)
45. Ans. (a)
46. Ans. (c)
47. Ans. (d) A very high compression ratio is favoured for a CI engine, in order to attain high THERMAL efficiency without knocking.
48. Ans. (a)
49. Ans. (a)
50. Ans. (b)
51. Ans. (c)
52. Ans. (b) Increasing coolant temperature will reduce knocking in C I engine.
53. Ans. (c) Increasing the engine speed reduces knock in SI engine. Decreasing the engine speed reduces knock in CI engine.
54. Ans. (a)
55. Ans. (b) Volumetric efficiency will reduce if fresh charge filled is reduced. i.e. inlet valve closes before bottom dead centre.
56. Ans. (c)
57. Ans. (a)

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 2000}{60} \text{rad/s}$$

$$\theta = \omega t = \frac{2\pi \times 2000}{60} \times \frac{1.5}{1000} \text{ rad} = \frac{2 \times 180 \times 2000 \times 1.5}{60 \times 1000} = 18^0$$

58. Ans. (c) Mixing of the fuel more thoroughly. Improved mixing had to be accomplished by imparting additional motion to the air, most commonly by induction-produced air swirls or a radial movement of the air, called squish, or both, from the outer edge of the piston toward the centre. Various methods have been employed to create this swirl and squish.

59. Ans. (b) In divided combustion chamber, the restrictions or throat between chambers results in high velocities which helps in rapid mixing of fuel with air. Thus high injection pressure is not required for atomization.
60. Ans. (d)
61. Ans. (d) Pre-combustion diesel engines use lower injection pressures
62. Ans. (b)
63. Ans. (c)
64. Ans. (d) Specific fuel consumption decreases as the power capacity of the engine increases.
65. Ans. (a)
66. Ans. (d) Due to higher compression ratio. Specific power output (means power /weight) of a diesel engine is lower than that of the SI engine. That so why we use SI engine for light vehicles.
67. Ans. (b)
68. Ans. (d)

Conventional Questions with Answers

Q1. The spark plug is fixed at 18° before top dead centre (TDC) in an SI engine running at 1800 r.p.m. It takes 8° of rotation to start combustion and get into flame propagation mode. Flame termination occurs at 12° after TDC. Flame front can be approximated as a sphere moving out from the spark plug which is offset 8 mm from the centre line of the cylinder whose bore diameter is 8.4 cm. Calculate the effective flame front speed during flame propagation. The engine speed is increased to 3000 r.p.m. and subsequently as a result of which the effective flame front speed increases at a rate such that it is directly proportional to 0.85 times of engine speed. Flame development after spark plug firing still takes 8° of engine rotation. Calculate how much engine rotation must be advanced such that the flame termination again occurs at 12° after TDC. [IES-2010, 10-Marks]

Ans. Insufficient data.

3. Carburetion and Fuel Injection

OBJECTIVE QUESTIONS (GATE, IES & IAS)

Previous Years GATE Questions

Complete carburettor

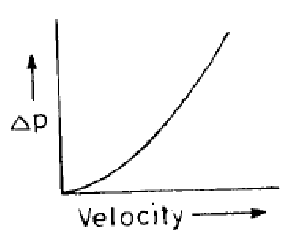
Q1. At the time of starting, idling and low speed operation, the carburretor supplies a mixture which can be termed as **[GATE-2004]**
(a) Lean (b) slightly leaner than stoichiometric
(c) stoichiometric (d) rich

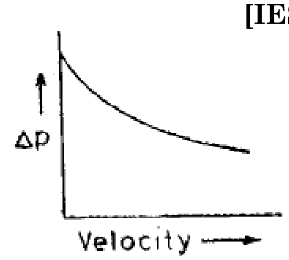
Previous Years IES Questions

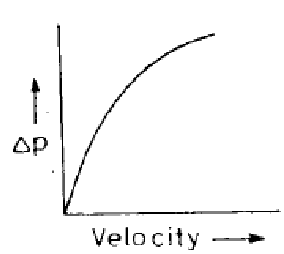
A simple or elementary carburettor

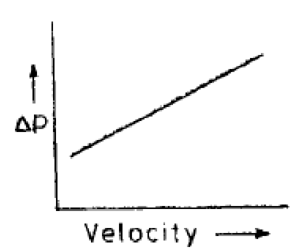
Q1. The essential function of the carburettor in a spark ignition engine is to:
(a) Meter the fuel into air stream and amount dictated by the load and speed
(b) Bring about mixing of air and fuel to get a homogeneous mixture **[IES-1992]**
(c) Vaporise the fuel
(d) Distribute fuel uniformly to all cylinders in a multi cylinder engine and also vaporise it.

Q2. Which one of the following curves is a proper representation of pressure differential (y-axis) vs velocity of air (x-axis) at the throat of a carburettor? **[IES-1993]**

(a)


(b)


(c)


d)


Q3. **Assertion (A):** A simple or elementary carburettor provides progressively rich mixture with increasing air flow **[IES-2004]**
Reason (R): The density of the air tends to increase as the rate of air flow increases.
(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

Q4. **Assertion (A):** A simple carburettor which is set to give a correct mixture at low air speeds will give a progressively rich mixture as the air speed is increased. **[IES-1995]**
Reason (R): As the pressure difference over the jet of a simple carburettor increases the weight of petrol discharge increases at a greater rate than does the air supply.
(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

Complete carburettor

Q5. **Consider the following statements:** **[IES-2005]**
1. **In a carburettor the throttle valve is used to control the fuel supply.**
2. **The fuel level in the float chambers is to be about 4 to 5 mm below the orifice level of main jet.**
3. **An idle jet provides extra fuel during sudden acceleration.**
4. **A choke valve restricts the air supply to make the gas richer with fuel.**

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

Q6. **Match List I with List II and select the correct answer using the codes given below the lists :** **[IES-1993]**

List I (Elements of a complete carburetor)	List II (Rich-mixture requirement)
A. Idling system	**1. To compensate for dilution of charge**
B. Economizer	**2. For cold starting**
C. Acceleration pump	**3. For meeting maximum power range of operation**
D. Choke	**4. For meeting rapid opening of throttle**

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

Q7. **Compensating jet in a carburettor supplies almost constant amount of petrol at all speeds because** **[IES-1996]**
(a) The jet area is automatically varied depending on the suction.
(b) The flow from the main jet is diverted to the compensating jet with increase in speed.
(c) The diameter of the jet is constant and the discharge coefficient is invariant.
(d) The flow is produced due to the static head in the float chamber.

Q8. **Assertion (A):** One of the important requirements of a carburettor is to supply lean mixture at starting.
Reason (R): A rather lean mixture is required at No-load and low-load operation of a SI engine. **[IES-1997]**
(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

Q9. Consider the following statements for a carburettor: [IES-2004]
1. Acceleration jet is located just behind the throttle value
2. Idle jet is located close to the choke
3. Main jet alone supplies petrol at normal engine speeds
Which of the statements given above are correct?
(a) 1, 2 and 3 (b) 1 and 2 (c) 2 and 3 (d) 1 and 3

Q10. In some carburettor, meter rod and economiser device is used for [IES-1998]
(a) Cold starting (b) idling
(c) Power enrichment (d) acceleration

Q11. Oxides of nitrogen in the engine exhaust can be reduced by which of the following methods?
1. Decrease in compression ratio
2. Exhaust gas recirculation
3. Use of 5% lean mixture
4. Use of oxidation catalysts in exhaust manifold
Select the correct answer using the code given below: [IES-2008]
(a) 1 and 2 only
(b) 1 and 3 only
(c) 1, 2 and 4
(d) 2 and 4 only

Q12. Consider the following statements: [IES-2000]
1. Recycling exhaust gases with intake increases emission of oxides of nitrogen from the engine.
2. When the carburettor throttle is suddenly opened, the fuel air mixture leans out temporarily causing engine stall.
3. The effect of increase in altitude on carburettor is to enrich the entire part-throttle operation.
4. Use of multiple venturi system makes it possible to obtain a high velocity air stream when the fuel is introduced at the main venturi throat.
Which of these statements are correct?
(a) 1 and 3 (b) 1 and 2 (c) 2 and 3 (d) 2 and 4

Q13. Consider the following statements: [IES-2000]
In down draft carburettor, a hot spot is formed at the bottom wall which is common for intake and exhaust manifolds. This helps to
1. Improve evaporation of liquid fuel
2. Provide higher thermal efficiency
3. Reduce fuel consumption
4. Lower the exhaust gas temperature
Which of these statements are correct?
(a) 1, 2 and 4 (b) 1, 2 and 3 (c) 1, 3 and 4 (d) 2, 3 and 4

Petrol injection

Q14. Consider the following statements regarding the advantages of fuel injection over carburetion in S.I. engines:
1. Higher power output and increased volumetric efficiency. [IES-2001]
2. Simple and inexpensive injection equipment.
3. Longer life of injection equipment.
4. Less knocking and reduced tendency for back-fire.
Select the correct answer using the codes given below:

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

Requirements of a diesel injection system

Q15. Where does mixing of fuel and air take place in case of diesel engine?
(a) Injection pump (b) Injector **[IES-2006]**
(c) Engine cylinder (d) Inlet manifold

Q16. **Assertion (A):** Air injection system finds wide application in modern diesel engines.
Reason (R): Very good atomization of fuels is attained by the air injection system.
(a) Both A and R are individually true and R is the correct explanation of A **[IES-1994]**
(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

Q17. Consider the following statements: **[IES-1996]**
The injector nozzle of a CI engine is required to inject fuel at a sufficiently high pressure in order to
1. be able to inject fuel in a chamber of high pressure at the end of the compression stroke.
2. Inject fuel at high velocity to facilitate atomization.
3. Ensure that penetration is not high.
Of the above statements
(a) 1 and 2 (b) 1 and 3 (c) 2 and 3 (d) 1, 2 and 3

Fuel pump

Q18. Generally, in Bosch type fuel injection pumps, the quantity of fuel is increased or decreased with change in load, due to change in **[IES-1994]**
(a) Timing of start of fuel injection. (b) Timing of end of fuel injection
(c) Injection pressure of fuel (d) velocity of flow of fuel

Previous Years IAS Questions

A simple or elementary carburettor

Q1. **Assertion (A):** The carburetor in a petrol engine is categorized as a closed loop control system. **[IAS-2001]**
Reason (R): There is no method by which the air-fuel ratio is measured in the carburetor.
(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

ANSWER WITH EXPLANATION

Previous Years GATE Answers

1. Ans. (d)

Previous Years IES Answers

1. Ans. (a)
2. Ans. (a) The relationship between $\Delta P \; and \; v \; is \; \Delta P \propto v^2$ [parabolic $x^2 = 4Ay$] which is represented by curve (a).
3. Ans. (c)
4. Ans. (a) Both A and R are true and R provides correct explanation for A
5. Ans. (a) *1 is false:* In a carburetor the throttle valve is used to control the air-fuel mixture supply.
3 is false: An Idle jet provides extra-fuel during idling and low speed.
6. Ans. (b) The idling system is used to compensate for dilution of charge, economizer is for meeting maximum power range of operation, acceleration pump for meeting rapid opening of throttle valve, and choke is used for cold starting.
7. Ans. (b)
8. Ans. (d) At starting rich mixture is required
9. Ans. (d)
10. Ans. (c) An economizer is a valve which remains closed at normal speed and gets opened to supply enriched mixture at full throttle operation.
11. Ans. (c) Decrease in compression ratio will decrease the temperature therefore decrease NO_x emission.
12. Ans. (c)
13. Ans. (a)
14. Ans. (d)
15. Ans. (c)
16. Ans. (a) Both A and R are correct and R is correct explanation of A.
17. Ans. (a)
18. Ans. (b) The quantity of fuel is varied by rotating helix on pump plunger, i.e. timing the end of fuel injection.

Previous Years IAS Answers

1. Ans. (c) There are several methods by which the air-fuel ratio is measured in the carburettor.

Q1. Derive an expression for air/fuel ratio of a carburettor by
(i) Neglecting compressibility of air
(ii) Taking compressibility effects into account. [IES-2009, 8 + 7 = 15-Marks]

Ans. **(i)** Neglecting compressibility effect, we have

$$\frac{P_1}{\rho_a} - \frac{P_2}{\rho_a} = \frac{C_2^2}{2}$$

$$\Rightarrow \; C_2 = \sqrt{2\left[\frac{P_1 - P_2}{\rho_a}\right]}$$

$$m_a = A_2 \, C_2 \, \rho_a$$

$$= A_2 \sqrt{2\rho_a (P_1 - P_2)}$$

$\therefore$ **air / fuel ratio**

$$= \frac{m_a}{m_f} = \frac{A_2}{A_f}\sqrt{\frac{\rho_n (P_1 - P_2)}{\rho_f (P_1 - P_2 - gz\rho_f)}}$$

$$\text{If } z = 0, \; \frac{m_a}{m_f} = \frac{A_2}{A_f}\sqrt{\frac{\rho_a}{\rho_f}}$$

(ii) Let carburetor with the tip of the fuel nozzle meters above the fuel level in the float chamber, then applying energy equation

$$q - w = (h_2 - h_1) + \frac{1}{2}\left(c_2^2 - c_1^2\right)$$

Where q = heat
w = work
h = enthalpy
c = velocity

Assuming, adiabatic flow, we get
$Q = 0$, $w = 0$ and $c_1 = 0$

Hence $c_2 = \sqrt{2(h_1 - h_2)}$

Assuming gas behaves ideally so we have

$$h = c_p T$$

$$\Rightarrow c_2 = \sqrt{2c_p (T_1 - T_2)} \qquad \text{... (i)}$$

As the flow process from inlet to the venturing throat, we can assume isentropic process, so we have

$$\left(\frac{T_2}{T_1}\right) = \left(\frac{P_2}{P_1}\right)^{\left(\frac{\gamma - 1}{\gamma}\right)}$$

$$\Rightarrow T_1 - T_2 = T_1\left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right]$$

Substituting in equation (i), we get

$$c_2 = \sqrt{2c_p T_1\left[1 - \left(\frac{P_2}{P_1}\right)^{\left(\frac{\gamma-1}{\gamma}\right)}\right]}$$

Now, mass flow of air,

$$m_a = p_1 A_1 c_1 = p_2 A_2 c_2$$

Where A_1, A_2 are cross – sectional areas at the air inlet and outlet.

To calculate mass flow rate of air, we have

$$\frac{P_1}{p_1^{\gamma}} = \frac{P_2}{p_2^{\gamma}}$$

$$\Rightarrow p_2 = \left(\frac{P_2}{P_1}\right)^{1/\gamma} p_1$$

$$\dot{m}_a = \left(\frac{P_2}{P_1}\right)^{1/\gamma}$$

$$p_1 \sqrt{2c_p T_1 \left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

$$\dot{m}_a = \frac{A_1 p_1}{R\sqrt{T_1}}$$

$$\sqrt{2c_p \left[\left(\frac{P_2}{P_1}\right)^{2/\gamma} - \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}\right]} \quad \text{..... (ii)}$$

In order to calculate air fuel ratio, fuel flow rate is to be calculated. As the fuel is in incompressible, applying Bernoulli's equation.

$$\frac{p_1}{\rho_f} - \frac{p_2}{\rho_f} = \frac{c_f^2}{2} + gz$$

Where

ρ_f = density of fuel

c_f = fuel velocity at the nozzle exit

Z = height of the nozzle exit above the level of fuel in the float bowl

$$\Rightarrow c_f = \sqrt{2\left[\frac{p_1 - p_2}{\rho_f} - gz\right]}$$

Mass flow rate of fuel,

$$\dot{m}_f = A_f c_f \rho_f$$

$$= A_f \sqrt{\left(2\rho_f p_1 - p_2 - gz\rho_f\right)} \quad \text{...... (iii)}$$

Where

A_f = area of the cross–section of the nozzle

ρ_f = density of the fuel.

$\therefore$ A/F ratio

$$= \frac{A_2 p_1 \phi}{\sqrt{2T_1 \rho_f \left(p_1 - p_2 - gz\rho_f\right)}} \quad \text{........ (iv)}$$

$$\text{where } \phi = \left(\frac{p_2}{p_1}\right)^{2/\gamma} - \left(\frac{p_2}{p_1}\right)^{\frac{\gamma+1}{\gamma}}$$

But $C_P = 1.005$ **J/ kg.**

$R = 287$ **J /kg K and**

$\gamma = 1.4$

$$\therefore \quad \phi = \sqrt{\left(\frac{p_2}{p_1}\right)^{1.43} - \left(\frac{p_2}{p_1}\right)^{1.71}}$$

So equation (iv) is the required equation.

Q2. **Drive an expression for the diameter of the injector orifice to spray fuel Q cm^3/cycle/cylinder in terms of injection pressure $p_{inj}\left(kN/m^2\right)$, combustion chamber pressure $p_{cy1}\left(kN/m^2\right)$, density of fuel $\rho_f\left(kg/cm^3\right)$ and period of injection τ seconds.**
Calculate the diameter of the injectgor orifice of a six-cylinder, 4-stroke CI engine using the following data:
Brake power = 250 kW; Engine speed = 1500 r.p.m; BSFC = 0.3 kg/kW Cylinder pressure = 35 bar; Injection pressure = 200 bar; Specific gravity of fuel = 0.88; Coefficient of discharge of the fuel orifice = 0.92; Duration of injection = 36°C of crank angle. **[IES-2007, 15-Marks]**

Ans. **Given:** For CI Engine,
Quantity of fuel sprayed
$= \mathbf{2\ cm^3/cycle/cylinder}$

$\mathbf{p_{inj}} =$ Injection pressure $\mathbf{kN/m^2}$

$\mathbf{p_{cyl}} =$ Combustion chamber's pressure $\mathbf{kN/m^2}$

$\rho_f =$ Density of fuel, $\mathbf{kg/cm^3}$

t = Period of injection, second.
Now velocity of fuel through injector orifice

$$v_f = C_d\sqrt{2gh}$$

where h = differential pressure head between injection and cylinder pressure

$$h = \frac{\left(p_{inj}-p_{cyl}\right)\times 10^3}{\rho_f g\times 10^6} = \frac{\left(p_{inj}-p_{cyl}\right)}{\rho_f\times 10^3\times g}\,m$$

$$v_f = C_d\sqrt{\frac{2\left(p_{inj}-p_{cyl}\right)}{\rho_f\times 10^3}}\,m/s$$

Now volume of fuel injected/cylinder/sec = Area of orifice × fuel jet velocity × time of one injection × number of injection/sec for one orifice

$$= \left(\frac{\pi}{4}d^2\right)\times v_f\times\left(\frac{\theta}{360}\times\frac{60}{N}\right)\times\frac{N_i}{60}$$

For one cycle, $\theta = 360$

$$\therefore Q\times 10^{-6}\,m^3/cycle/cylinder$$

$$= \left(\frac{\pi}{4}d^2\right)\times v_f\times\frac{60}{N}\times\frac{N_i}{60}$$

i.e. $$Q\times 10^{-6} = \frac{\pi}{4}d^2\times v_f\times t$$

i.e. $$d^2 = \frac{4Q\times 10^{-6}}{\pi\times t\times C_d\sqrt{\frac{2\left(p_{inj}-p_{cyl}\right)}{\rho_f\times 10^3}}}$$

$$d = \left(\frac{4Q}{\pi t\times c_d}\right)^{1/2}\left(\frac{\rho_f\times 10^3}{2\left(p_{inj}-p_{cyl}\right)}\right)^{\frac{1}{4}}\times 10^{-2} = \left(\frac{4Q}{\pi t c_d}\right)^{\frac{1}{2}}\left[\frac{\rho_f\times 10^3}{2\left(p_{inj}-p_{cyl}\right)}\right]^{\frac{1}{4}}\ cm$$

Now, given for 4 stroke CI engine, number of cylinders = 6
B.P. = 250 kW.
Engine speed = N = 1500 r.p.m
BSFC = 0.3 kg/kW

$\mathbf{p_{cyl}}$ $\mathbf{35\ bar = 35\times 10^5\,N/m^2}$

$\mathbf{p_{cyl}}$ $\mathbf{200\ bar = 200 \times 10^5\ N / cm^2}$

Specific gravity of fuel = 0.88

$\rho_1 = \mathbf{880\ kg / m^3}$

$\mathbf{C_d}$ = coefficient of discharge for fuel orifice = 0.92

Duration of injection = θ = 36° of crank

Now, time deviation (period) of injection

$$= \frac{\mathbf{36}}{\mathbf{360} \times \frac{\mathbf{1500}}{\mathbf{60}}} = \mathbf{0.4 \times 10^{-2}\ sec}$$

∴ Velocity of injection $\mathbf{v_{inj}}$

$$= \mathbf{C_d}\sqrt{\frac{2(p_{inj} - p_{cyl})}{\rho_f}} \quad = \mathbf{0.92}\sqrt{\frac{\mathbf{2(200-35) \times 10^5}}{\mathbf{880}}} = \mathbf{178.16\ m / sec}$$

Fuel consumed/hour = BSFC × power output

= 0.3 × 250 = 75 kg

Fuel consumption/cylinder

$$\frac{\mathbf{75}}{\mathbf{6}} = \mathbf{12.5\ kg / hr}$$

Fuel consumption/cycle

$$= \frac{\mathbf{Fuel\ consumption / min\,ute}}{\mathbf{n}}$$

Where $\mathbf{n} = \frac{\mathbf{N}}{\mathbf{2}}$ for 4 stroke engine = 750

∴ Fuel consumption/cycle

$$= \frac{\mathbf{12.5 / 60}}{\mathbf{750}} = \mathbf{0.277 \times 10^{-3}\ kg}.$$

Volume of fuel injected/cycle

$$= \frac{\mathbf{0.277 \times 10^{-3}}}{\mathbf{880}} = \mathbf{0.3148\ cc / cycle = 0.3148 \times 10^{-6}\ m^3 / cycle}.$$

Now, injection orifice area,

$$\mathbf{A_f} = \frac{\mathbf{Volume\ of\ fuel\ injected / cycle}}{\mathbf{Injection\ velocity \times Injection\ time}}$$

$$\mathbf{A_f} = \frac{\mathbf{0.3148 \times 10^{-6}}}{\mathbf{178.16 \times 4 \times 10^{-3}}} = \mathbf{0.4417 \times 10^{-6}\ m^2}$$

Now, area of orifice $= \frac{\pi}{\mathbf{4}}\mathbf{d^2} = \mathbf{0.4417 \times 10^{-6}\ m^2}$

Diameter of injector orifice,

$$\mathbf{d} = \sqrt{\frac{\mathbf{4 \times 0.4417 \times 10^{-6}}}{\pi}} = \mathbf{0.75 \times 10^{-3}}\ \mathrm{m} \quad = \mathbf{0.75\ mm}$$

4. Fuels

OBJECTIVE QUESTIONS (GATE, IES & IAS)

Previous Years GATE Questions

Diesel fuels

Q1. Alcohols are unsuitable as diesel engine fuels because [GATE-1992]
(a) The cetane number of alcohol fuels is very low which prevents their ignition by compression
(b) The cetane number of alcohol fuels is very high which prevents their ignition by compression
(c) The cetane number of alcohol fuels is very low which prevents their ignition by compression
(d) None of the above

Cetane Number

Q2. [GATE-1996]

List I	List II
(A) Cetane number	**1. Ideal gas**
(B) Approach and range	**2. Van der Waals gas**
(C) $\left(\frac{\delta T}{\delta p}\right)_h \neq 0$	**3. S.l. engine**
(D) dh = c_p dT, even when pressure varies	**4. C.l. engine p**
	5. Cooling towers
	6. Heat exchangers

Code:

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

Previous Years IES Questions

Q1. What is the flash point of a liquid fuel? [IES-2006]
(a) The temperature at which the fuel ignites spontaneously with a bang
(b) The temperature at which the fuel emits vapours at a rate which produces an inflammable mixture with air
(c) The temperature at which the fuel ignites with a clearly
(d) The temperature at which the fuel ignites without a spark

Fuels for spark-ignition engines

Q2. In a petrol engine car, which one of the following performance characteristics is affected by the front-end volatility of the gasoline used? [IES-2000]
(a) Hot starting and vapour lock

(b) Engine warm-up and spark plug fouling
(c) Spark plug fouling and hot starting
(d) Vapour lock, engine warm-up and spark plug fouling

Q3.

$$
\begin{array}{ccccccccc}
 & & H & & H & & H & & H & & \\
 & & | & & | & & | & & | & & \\
H & - & C & - & C & - & C & - & C & - & H \\
 & & | & & | & & | & & | & & \\
 & & H & & H & & H & & H & &
\end{array}
$$

Which one of the following is represented by the molecular structure of the paraffin family of hydrocarbon fuel given above, for an IC engine?
(a) Ethane (b) Propane
(c) Butane (d) Hexane **[IES 2007]**

Q4. Which one of the following fuels can be obtained by fermentation of vegetable matter?
(a) Benzene (b) Diesel (c) Gasoline (d) Alcohol **[IES-2005]**

Knock rating of SI engine fuels

Q5. In a SI Engine, which one of the following is the correct order of the fuels with increasing detonation tendency? **[IES-1997]**
(a) Paraffins, Olefins, Naphthenes, Aromatics
(b) Aromatics, Naphthenes, Paraffins, Olefins
(c) Naphthenes, Olefins, Aromatics, Paraffins
(d) Aromatics, Naphthenes, Olefins, Paraffins

Octane number requirement (ONR)

Q6. Consider the following statements regarding knock rating of SI engine fuels:
1. **Iso-octane is assigned a rating of zero octane number.** **[IES-2002]**
2. **Normal heptane is assigned a rating of hundred octane number**
3. **Iso-octane is assigned a rating of hundred octane number**
4. **Normal heptane is assigned a rating of zero octane number**

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

Q7. Assertion (A): Octane number is used for rating of fuels in spark ignition engine.
Reason (R): Octane number of a fuel is defined as percentage by volume, of iso-octane in a mixture of iso-octane and ex-methylnaphthalene. **[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

Q8. Reference fuels for knock rating of SI engine fuels would include **[IES-1994]**
(a) iso- octane and alpha-methyl naphthalene
(b) Normal octane and aniline.
(c) iso-octane and n-hexane
(d) n-heptane and iso - octane.

Q9. Assertion (A): Iso-octane has been chosen as the reference for S.I. engine fuels and has been assigned a value of octane number 100. **[IES-1993]**

Reason (R): Among the fuels, iso-octane ensures the highest compression ratio at which an S.I. engine can be operated without knocking.
(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

Cetane Number

Q10. The two reference fuels used for cetane rating are [IES-1995]
(a) cetane and iso-octane (b) cetane and tetraethyl lead
(c) cetane and n-heptane (d) cetane and α-methyl naphthalene.

Q11. The Cetane number of automotive diesel fuel used in India is in which one of the following ranges? [IES 2007]
(a) 30 – 40 (b) 41 – 50 (c) 51 – 60 (d) 61 – 70

Q12. Consider the following statements [IES-2001]
1. Motor gasoline is a mixture of various hydrocarbons with a major proportion being aromatic hydrocarbons.
2. Compressed natural gas is mainly composed of methane.
3. Producer gas has a predominant component of hydrogen with lesser proportion of carbon monoxide.
4. Cetane number of fuel used in diesel engines in India is in the range of 80 to 90.
Which of these statements are correct?
(a) 1 and 2 (b) 1 and 3 (c) 2, 3 and 4 (d) 1, 2, 3 and 4

Q13. Consider the following statements regarding n-Cetane: [IES-1996]
1. It is a standard fuel used for knock rating of diesel engines.
2. Its chemical name is n-hexadecane
3. It is a saturated hydrocarbon of paraffin series.
4. It has long carbon chain structure.
Of the above correct statements are
(a) 1, 3 and 4 (b) 1, 2 and 3 (c) 1, 2 and 4 (d) 2, 3 and 4

ANSWER WITH EXPLANATION

Previous Years GATE Answers

1. Ans. (a)
2. Ans. (a)

Previous Years IES Answers

1. Ans. (b)
2. Ans. (a)
3. Ans. (c)
4. Ans. (d)
5. Ans. (d)
6. Ans. (c)
7. Ans. (c) Octane number of a fuel is defined as percentage by volume, of iso-octane in a mixture of iso-octane and n-heptane.
8. Ans. (d) Reference fuel for knock rating of SI engine fuels would include n-heptane and iso-octane.
9. Ans. (a) Both assertion and reason given are true. Also the reason R is the correct explanation of the assertion.
10. Ans. (d) Two reference fuels for cetane rating are cetane and α -methyl naphthalene.
11. Ans. (b) Indian Diesel: Year 2000: CN48, Sulfur 0.25%
Year 2010: CN48, sulfur 350PPM will be Euro 3
Note: sulfur 50PPM will be Euro4
12. Ans. (a) Cetane number of fuel used in diesel engines in India is in the range of 55 to 65
13. Ans. (a)

Conventional Questions with Answers

Q1. What are the advantages and disadvantages of using hydrogen as an I.C. Engine fuel?
Explain one method by which hydrogen can be used in C.I. Engine.

[IES-2006, 10-Marks]

Ans. Advantages of using hydrogen as I.C. engine fuel

(i) Low emission
(ii) Fuel availability; There are a number of different ways of making hydrogen, including electrolysis of water.
(iii) Fuel leakage to environment is not a pollutant.
(iv) High energy content per volume when stored as a liquid. This would give a large vehicle range for a given fuel tank capacity.

Disadvantages

(i) Storage problem; Hydrogen can be stored as a cryogenic liquid or as a compressed gas. This will required a thermally super insulated fuel tank or high pressure vessel.
(ii) Difficult to refuel & the possibility of detonation.
(iii) Poor engine volumetric efficiency.
(iv) Fuel cost would be high at present day technology and availability.
(v) High $\mathbf{No_X}$ emission because of high flame temperature.
(vi) Can detonate.

Use of hydrogen in C.I. engine

Hydrogen is introduced directly into the cylinder at the end of compression. Since the self ignition temperature of hydrogen is very high, the gas spray is made to impinge on a hot glow plug in the combustion chamber, that is by surface ignition. It is also possible to feed a very lean hydrogen air mixture during the entrance into an engine and then inject the bulk of the hydrogen towards the end of hydrogen stroke.

5. Supercharging

OBJECTIVE QUESTIONS (IES)

Previous Years IES Questions

Objectives of supercharging

Q1. What is the main objective of supercharging of the engine? [IES 2007]
(a) To reduce the mass of the engine per brake power
(b) To reduce space occupied by engine
(c) To increase the power output of engine
(d) All of the above

Q2. What is the purpose of employing supercharging for an engine? [IES-2006]
(a) To provide forced cooling air
(b) To raise exhaust pressure
(c) To inject excess fuel for coping with higher load
(d) To supply an intake of air at a density greater than the density of the surrounding atmosphere

Q3. Consider the following statements: [IES-2006]
1. Supercharging increases the power output of an engine.
2. Supercharging increases the brake thermal efficiency considerably.
3. Supercharging helps scavenging of cylinders.
Which of the statements given above are correct?
(a) Only 1 and 2 (b) Only 2 and 3
(c) Only 1 and 3 (d) 1,2 and 3

Supercharging of CI Engine

Q4. Consider the following statements with reference to supercharging of I.C. engines:
1. Reciprocating compressors are invariably used for high degree of supercharging
2. Rotary compressors like roots blowers are quite suitable for low degree of supercharging [IES-2004]
3. Axial flow compressors are most commonly employed for supercharging diesel engines used in heavy duty transport vehicles
4. Centrifugal compressors are used for turbo -charging
Which of the statements given above are correct?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 4 (d) 2 and 4

Q5. Surging basically implies [IES-1996]
(a) Unsteady, periodic and reversed flow.
(b) Forward motion of air at a speed above sonic velocity.
(c) The surging action due to the blast of air produced in a compressor.
(d) Forward movement of aircraft.

Q6. Which one of the following types of compressors is mostly used for supercharging of I.C. engines? **[IES-1996]**
(a) Radial flow compressor (b) Axial flow compressor
(c) Roots blower (d) Reciprocating compressor

Effect of supercharging on performance of the engine

Q7. Assertion (A): The CI engine is basically more suitable for supercharging than the SI engine. **[IES-2000]**
Reason (R): In the CI engine supercharging tends to prevent diesel knocking.
(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

Q8. Consider the following statements:
1. Supercharging increases the power output and increases the volumetric efficiency.
2. Supercharging is more suitable for S.I. engines than C.I. engines. [IES-2005]
3. The limit of supercharging for an S.I. engine is set by knock while that for a C.I. engine is set by thermal loading.
Which of the statements given above are correct?
(a) 2 and 3 (b) 1, 2 and 3 (c) 1 and 3 (d) 1 and 2

ANSWER WITH EXPLANATION

Previous Years IES Answers

1. Ans. (d) All of the above are objective of supercharging. But main objective is to increase the power output of engine.
2. Ans. (d)
3. Ans. (d)
4. Ans. (d)
5. Ans. (a)
6. Ans. (c) Roots blower is mostly used for supercharging of I.C. engines
7. Ans. (a)
8. Ans. (c) Supercharging is more suitable for C.I. engines than S.I. engines.

6. Jet Propulsion

OBJECTIVE QUESTIONS (GATE & IES)

Previous Years GATE Questions

Applications of rockets

Q1. An air breathing aircraft is flying where the air density is half the value at ground level. With reference to the ground level, the air-fuel ratio at this altitude will be [GATE-1998]

(a) $\sqrt[3]{2}$ (b) $\sqrt{2}$ (c) 2 (d) 4

Previous Years IES Questions

Turbo-jet

Q1. Consider the following statements: [IES-1996]
In open cycle turbo-jet engines used in military aircraft, reheating the exhaust gas from the turbine by burning more fuel is used to increase.
1. Thrust 2. The efficiency of engine 3. The range of aircraft.
Of these correct statements are

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

Q2. Which one of the following is correct?
The turbine of the turbo-prop engine as compared to that of the turbojet engine is

(a) Similar (b) Smaller
(c) Bigger (d) Unpredictable **[IES 2007]**

Q3. The propulsive efficiency of a turbojet aircraft approaches 100% when the thrust approaches [IES-2003]

(a) Maximum (b) 50% of the maximum
(c) 25% of the maximum (d) Zero

Q4. Assertion (A): Compared to a turbo-jet engine, a turbo-prop engine has a higher power for take-off and higher propulsive efficiency at low speeds. **[IES-1997]**
Reason (R): By mounting the propeller on the turbine shaft, the propeller can be run at a very high speed to obtain higher efficiency.

(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

Q5. In a turbojet engine, subsequent to heat addition to compressed air, to get the power output, the working substance is expanded in [IES-1996]

(a) Turbine blades, which is essentially an isentropic process.

(b) Turbine blades, which is a polytropic process.
(c) Exit nozzle, which is essentially an isentropic process.
(d) Exit nozzle, which is a constant volume process.

Q6. **Assertion (A):** In the subsonic range the propulsive efficiency of a rocket is less than that of a turbojet. **[IES-1995]**
Reason (R): The jet velocity of rocket is independent of forward motion.
(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

Q7. **The absolute jet exit velocity from a jet engine is 2800 m/s and the forward flight velocity is 1400 m/s. The propulsive efficiency is** **[IES-2003]**
(a) 33.33 % (b) 40 % (c) 66.67 % (d) 90 %

Thrust, thrust power, propulsive efficiency and thermal efficiency

Q8. **Propulsion efficiency of a jet engine is given by (where u is flight velocity and V is jet velocity relative to aircraft).** **[IES-1995]**
(a) 2u/(V – u) (b) (V + u)/2u (c) 2u/(V + u) (d) (V-u)/2u

Q9. **For a jet propulsion unit, ideally the ratio of compressor work and turbine work is** **[IES-2002]**
(a) 2 (b) 1
(c) not related to each other (d) unpredictable

Q10. **Consider the following statements:**
In a turbojet engine, thrust may be increased by **[IES-1998]**
1. Increasing the jet velocity
2. Increasing the mass flow a rate of air
3. After burning of the fuel.
Of these statements
(a) 1 and 2 are correct (b) 2 and 3 are correct
(c) 1 and 3 are correct (d) 1, 2 and 3 are correct

Q11. **Assertion (A):** After burning increases the thrust of a jet engine.
Reason (R): The air fuel ratio of jet engine is high. **[IES-2009]**
(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.

Q12. **If V_j is the jet velocity and V_o is the vehicle velocity, the propulsive efficiency of a rocket is given by** **[IES-1994]**
(a) $\dfrac{2\left(V_o/V_j\right)}{1+\left(\dfrac{V_o}{V_j}\right)^2}$ (b) $\dfrac{V_o/V_j}{1+\left(\dfrac{V_o}{V_j}\right)^2}$ (c) $\dfrac{V_o}{V_o+V_j}$ (d) $\dfrac{V_j}{V_o+V_j}$

13. **Which one of the following is the correct expression for the propulsion efficiency of a jet plane (neglecting the mass of fuel)?** **[IES-2005]**

(a) $\eta_p = \dfrac{2}{\left(\dfrac{V_a}{V_j}\right)+1}$ (b) $\eta_p = \dfrac{2}{\left(\dfrac{V_j}{V_a}\right)+1}$ (c) $\eta_p = \dfrac{2}{\left(\dfrac{V_a}{V_j}\right)-1}$ (d) $\eta_p = \dfrac{2}{\left(\dfrac{V_j}{V_a}\right)-1}$

(Where V_j = velocity of jet relative to plane, V_a = velocity of the plane)

Q14. Consider the following statements regarding performance of turbojet engines:
1. The thrust decreases at higher altitude due to reduced density of air and consequently lower mass flow of air. **[IES-2004]**
2 At subsonic speeds, the effect of increased velocity is to increase the air flow and the thrust increases.
3. The relative velocity of jet with respect to the medium decreases at higher speeds which tends to reduce the thrust.
4 For turbojet engine the thrust of jet at subsonic speeds remains relatively constants.
Which of the statements given above are correct?
(a) 1, 2, 3 and 4 (b) 1 and 3 (c) 1, 2 and 4 (d) 2, 3 and 4

Q15. The theoretical mechanical efficiency of a jet engine (neglecting frictional and thermal losses), when driving a vehicle, has its maximum **[GATE-1992]**
(a) Only when the vehicle moves at sonic velocity
(b) When outlet gases approach zero absolute velocity
(c) When the vehicle speed approaches the magnitude of the relative velocity of gases at nozzle exit
(d) Only when the relative velocity at nozzle exit is at its maximum.

Q16. An aircraft flying horizontally at a speed of 900 km/h is propelled by a jet leaving the nozzle at a speed of 500 m/s. The propulsive efficiency is
(a) 0.334 (b) 0.426 (c) 0.556 (d) 0.667 **[IES-1999]**

Q17. The efficiency of jet engine is **[IES-2003]**
(a) Higher at high speeds (b) lower at low speeds
(c) Higher at high altitudes (d) same at all altitudes

Q18. Assertion (A): Propulsion efficiency of propeller driven aircraft is low at very high speeds.
Reason (R): At high speeds, shock waves are formed over propeller blades. **[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

Q19. Assertion (A): A bypass jet engine gives a better propulsive efficiency and better fuel economy than a straight jet engine. **[IES-1998]**
Reason (R): A bypass jet engine gives lower velocity of jet efflux than a straight jet engine.
(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

Q20. The thrust of a jet propulsion power unit can be increased by **[IES-1993]**
(a) Injecting water into the compressor
(b) Burning fuel after gas turbine
(c) Injecting ammonia into the combustion chamber

(d) all of the above

Turbo-prop

Q21. **Assertion (A):** The thrust of a turboprop engine increases with the increase in flight speed.
Reason (R): With the increase in flight speed, there is an increase in the pressure and density of the air at the compression inlet due to the ram effect. **[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

Q22. **Consider the following statements:** **[IES-1995]**
As compared to a turboprop, a turbojet
1. Can operate at higher altitudes
2. Can operate at higher flight velocities
3. Is more fuel efficient at lower speeds
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.

Q23. **In turbo prop, the expansion of gases takes place approximately** **[IES-2000]**
(a) 100% in the turbine
(b) 80% in the turbine and 20% in the nozzle
(c) 50% in the turbine and 50% in the nozzle
(d) 100% in the nozzle

Q24. **Which one of the following is the correct sequence of the position of the given components in a turboprop?** **[IES-1998]**
(a) Propeller, Compressor, Turbine, Burner
(b) Compressor, Propeller, Burner, Turbine
(c) Propeller, Compressor, Burner, Turbine
(d) Compressor, Propeller, Turbine, Burner

Q25. **Assertion (A):** The use of turboprop engine is limited to medium speed applications.
Reason (R): The efficiency of a turboprop engine decreases at higher speed. **[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

Q26. **Assertion (A):** Turbojet engine is superior to turboprop engine at all operating conditions. **[IES-1994]**
Reason (R): Efficiency of the propeller is low at high altitude and at high speeds.
(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

Q27. **A turbo prop is preferred to turbo-jet because** **[IES-1992]**
(a) It has high propulsive efficiency at high speeds
(b) It can fly at supersonic speeds
(c) It can fly at high elevations
(d) It has high power for take off

Rocket engines

Q28. Consider the following statements about a rocket engine: [IES-1997]
1. It is very simple in construction and operation.
2. It can attain very high vehicle velocity.
3. It can operate for very long duration.
Of these statements
(a) 1 and 3 are correct (b) 1 and 2 are correct
(c) 2 and 3 are correct (d) 1, 2 and 3 are correct

Q29. Consider the following statements relating to rocket engines: [IES-1996]
1. **The combustion chamber in a rocket engine is directly analogous to the reservoir of a supersonic wind tunnel.**
2. **Stagnation conditions exist at the combustion chamber.**
3. **The exit velocities of exhaust gases are much higher than those in jet engines.**
4. **Efficiency of rocket engines is higher than that of jet engines.**

Of these correct statements are
(a) 1, 3 and 4 (b) 2, 3 and 4 (c) 1, 2 and 3 (d) 1, 2 and 4

Q30. Only rocket engines can be propelled to 'SPACE' because [IES-1996]
(a) They can generate very high thrust.
(b) They have high propulsion efficiency.
(c) These engines can work on several fuels.
(d) They are not air-beating engines.

Q31. Which of the following performance advantages does a rocket engine have as compared to a turbojet engine? [IES-2009]
1. No altitude limitation **2. Higher efficiency**
3. Longer flight duration **4. No ram drag**
Select the correct answer from the code given below:
(a) 1 and 2 only (b) 1 and 4 only (c) 1, 2 and 3 (d) 2, 3 and 4

Requirements of an ideal rocket propellant

Q32. Assertion (A): Liquid oxygen-liquid hydrogen propellant system has a higher specific impulse relative to the liquid oxygen-hydrocarbon system. **[IES-1993]**
Reason (R): Hydrogen has a higher burning velocity than hydrocarbons.
(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

Q33. Match List I with List II in respect of chemical rocket engine and select the correct answer [IES-1994]

List I	**List II**
A. Ethyl alcohol	**1. Liquid oxidizer**
B. Nitrocellulose	**2. Liquid fuel**
C. Ammonium per chlorate	**3. Solid oxidizer**
D. Hydrogen peroxide	**4. Solid fuel**

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

Q34. Match List I with List II and select the correct answer using the codes given below the lists:

List I **List II** **[IES-1993]**

List I (Name of Propellant)	**List II (Type of propellant)**
A. Nitric acid	**1. Fuel**
B. Hydrogen	**2. Monopropellant**
C. Fuming nitric acid-hydrazine	**3. Oxidizer**
D. Methyl nitrate methyl alcohol	**4. Compounded liquid monopropellant**
	5. Hypergolic propellant

Codes:

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

Q35. In solid propellants rockets, ammonium picrate is usually added as:
(a) An additive (b) an inhibitor **[IES-1992]**
(c) A darkening agent (d) a plasticizer

Thrust work, propulsive work and propulsive efficiency

Q36. The relative jet exit velocity from a rocket is 2700 m/s. The forward flight velocity is 1350 m/s. What is the propulsive efficiency of the unit?
(a) 90% (b) 66.66%
(c) 50% (d) 33.33% **[IES-1998; 2004]**

Q37. Consider the following statements indicating a comparison between rocket and jet propulsion systems:
1. **Both rocket and jet engines carry the fuel and oxidant.** **[IES-2006]**
2. **Rockets do not employ compressor or propeller.**
3. **Rockets can operate in vacuum also.**
4. **Rockets can use solid fuels and oxidants.**

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

Q38. Consider the following statements:
The thrust of a rocket engine depends upon [IES-1998]
1. Effective jet velocity
2. Weight of the rocket
3. Rate of propellant consumption
Of these statements
(a) 1 and 2 are correct (b) 1 and 3 are correct
(c) 2 and 3 are correct (d) 1, 2 and 3 are correct

Q39. Assertion (A): A rocket engine can operate even in vacuum and in any fluid medium.
Reason (R): Rocket engine is a pure reaction engine, wherein a propulsive thrust is obtained as a reaction of momentum of ejected matter. **[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

ANSWER WITH EXPLANATION

Previous Years GATE Answers

1. Ans. (c)

Explanation. A/F ratio = $\frac{m_a}{m_f}$

where m_a – mass of air,

m_f – mass of fuel

$$\frac{(A/F\ ratio)_{ground}}{(A/F\ ratio)_{altitude}} = \frac{(m_a)_{ground}}{(m_a)_{altitude}}$$ as m_f is same at both places.

$$\frac{(m_a)_{ground}}{(m_a)_{altitude}} = \frac{V \times \rho_{ground}}{V \times \rho_{altitude}}$$ where 'V' is the volume of air taken in.

$$= \frac{1}{(1\backslash 2)} = 2$$

Previous Years IES Answers

1. Ans. (b)

2. Ans. (c) Though turbo-prop engine used in small aircraft due to its large number of stages its size is Big for same power.

3. Ans. (d) Propulsive efficiency $(\eta_p) = \frac{2}{\frac{C_j}{C_a}+1}$ and Thrust power (TP) = (C_j - C_a) C_a

Propulsive efficiency increases with increase in aircraft velocity (Ca), i.e. efficiency is maximum when thrust approach is zero.

4. Ans. (c)

5. Ans. (b)

6. Ans. (b) Both A and R are true but R is not correct explanation of A.

7. Ans. (c) Propulsive efficiency $(\eta_p) = \frac{2}{\frac{C_j}{C_a}+1} = \frac{2}{\frac{2800}{1400}+1} = 0.6667$

8. Ans. (c)

9. Ans. (b)

10. Ans. (d)

11. Ans. (b)

12. Ans. (a)

13. Ans. (b)

14 Ans. (d) The turbojet is almost a constant thrust engine.

15. Ans. (c)

16. Ans. (d) Propulsive efficiency $(\eta_p) = \frac{2\text{xVelocityofapproach of air } (V_a)}{\text{Velocityof jet relative to air plane } (V_j) + V_a}$

$$V_a = 900\text{km/hr} = 900 \times \frac{5}{18} = 250 \text{ m/s};\ V_j = 500 \text{ m/s}$$

$$\therefore \eta_p = \frac{2 \times 250}{500+250} = 0.667$$

17. Ans. (a)

18. Ans. (a)

19. Ans. (a

20. Ans. (a) The thrust of a jet propulsion power unit can be increased by injecting water into the compressor.

21. Ans. (d) The thrust of turboprop engine is proportional to $V_j - V_a$

(V_j = velocity of jet relative to engine and V_a = velocity of approach of air)

Further propulsive efficiency, $\eta_p = \dfrac{2}{\dfrac{V_j}{V_a} + 1}$

Therefore with increase in V_a, η_p increases but thrust decreases. Thus assertion A is false.

However reason R is true.

22. Ans. (b)

23. Ans. (b)

24. Ans. (c)

25. Ans. (c) In fact the efficiency increases with speed but thrust keeps on decreasing.

26. Ans. (d) A is false but R is true.

27. Ans. (d)

28. Ans. (d) All statements are correct.

29. Ans. (c)

30. Ans. (d) Rocket engines can be propelled to space because they are not air breathing engines

31. Ans. (b)

32. Ans. (a) Both assertion and reason are true and also R provides correct explanation for A.

33. Ans. (c)

34. Ans. (c)

35. Ans. (a)

36. Ans. (b) $\eta_{\text{propulsive}} = \dfrac{2}{\dfrac{C_j}{C_a} + 1} = \dfrac{2}{\dfrac{2700}{1350} + 1} = 66.66\%$

37. Ans. (c) 1 is false, jet engines absorb oxygen from atmosphere.

38. Ans. (b)

39. Ans. (a) Both A and R are true and R provides correct explanation for A.

7. IC Engine Performances

OBJECTIVE QUESTIONS (GATE & IES)

Previous Years GATE Questions

Q1. During a Morse test on a 4 cylinder engine, the following measurements of brake power were taken at constant speed. [GATE-2004]

All cylinders firing	**3037 kW**
Number 1 cylinder not firing	**2102 kW**
Number 2 cylinder not firing	**2102 kW**
Number 3 cylinder not firing	**2100 kW**
Number 4 cylinder not firing	**2098 kW**

The mechanical efficiency of the engine is

(a) 91.53% (b) 85.07% (c) 81.07% (d) 61.22%

Q2. With increasing temperature of intake air, IC engine efficiency [GATE-1998]

(a) Decreases (b) increases
(c) Remains same (d) depends on other factors

Q3. Brake thermal efficiency of the three types of reciprocating engines commonly used in road vehicles are given in the increasing order as

(a) 2 stroke Sl engine, 4 stroke Sl engine, 4 stroke Cl engine **[GATE-1992]**
(b) 2 stroke Sl engine, 4 stroke Cl engine, 4 stroke Sl engine
(c) 4 stroke Sl engine, 2 stroke SI engine, 4 stroke Cl engine
(d) 4 stroke Cl engine, 4 stroke Sl engine, 2 stroke Sl engine

Q4. An automobile engine operates at a fuel air ratio of 0.05, volumetric efficiency of 90% and indicated thermal efficiency of 30%. Given that the calorific value of the fuel is 45 MJ/kg and the density of air at intake is 1 kg/m^3, the indicated mean effective pressure for the engine is [GATE-2003]

(a) 6.075 bar (b) 6.75 bar (c) 67.5 bar (d) 243 bar

Previous Years IES Questions

Q1. In a variable speed S.I. engine, the maximum torque occurs at the maximum

(a) Speed (b) brake power **[IES-1999]**
(c) Indicated power (d) volumetric efficiency

Q2. In a Morse test for a 2-cylinder, 2-stroke, spark ignition engine, the brake power was 9 kW whereas the brake powers of individual cylinders with spark cut of were 4.25 kW and 3.75 kW respectively. The mechanical efficiency of the engine is [IES-1999]

(a) 90% (b) 80% (c) 45.5% (d) 52.5%

Q3. Consider the following statements: [IES-1993]

I. The performance of an S.I. engine can be improved by increasing the compression ratio.

II. Fuels of higher octane number can be employed at higher compression ratio.
Of these statements
(a) Both I and II are true (b) both I and II are false
(c) I is true but II is false (d) I is false but II is true

Q4. Besides mean effective pressure, the data needed for determining the indicated power of an engine would include [IES-1993]
(a) Piston diameter, length of stroke and calorific value of fuel
(b) Piston diameter, specific fuel consumption and calorific value of fuel
(c) Piston diameter, length of stroke and speed of rotation
(d) Specific fuel consumption, speed of rotation and torque

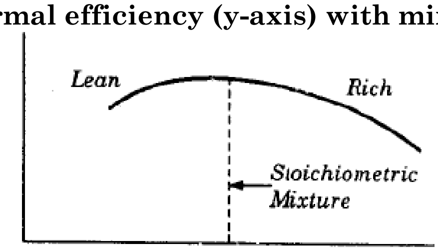
Q5. The method of determination of indicated power of multi-cylinder SI engine is by the use of [IES-1995]
(a) Morse test (b) Prony brake test
(c) Motorint test (d) Heat balance test.

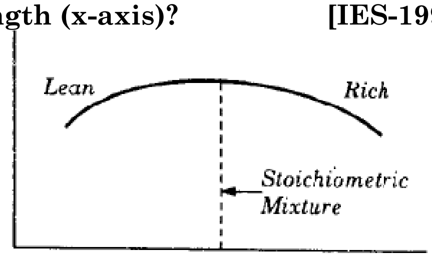
Q6. Match List-I with List-II and select the correct answer using the codes given below the lists:

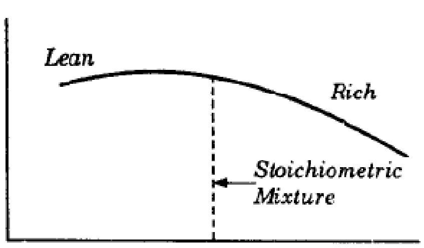
List-I	**List-II** [IES-2001]
A. Supercharging	**1. Multi-cylinder engine**
B. Morse test	**2. C.I. engine**
C. Heterogeneous combustion	**3. Calorific value**
D. Ignition quality of petrol	**4. Aircraft engine**
	5. Octane number
	6. Single cylinder S.I. engine

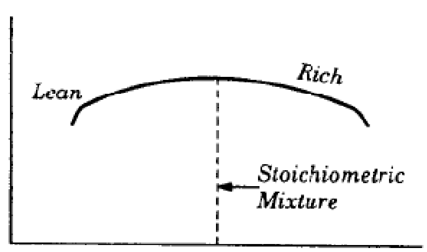
	A	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	4	1	2	5	(b)	1	3	4	2
(c)	5	4	2	3	(d)	1	4	2	3

Q7. Which one of the following figures correctly represents the variation of thermal efficiency (y-axis) with mixture strength (x-axis)? [IES-1997]

(*a*)


(*b*)


(*c*)


(*d*)


Q8. For a typical automobile C.I. engine, for conditions of increasing engine speed match List I with List II and select the correct answer using the codes given below the lists : [IES-1993]

List I **List II**
(Performance parameter) **(Tendency, qualitatively)**
A. Power output **1. Increasing and then decreasing,**

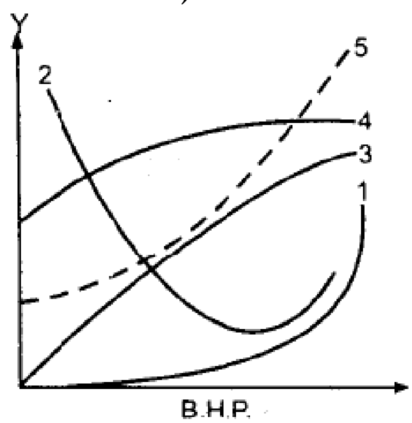
B. Torque 2. Decreasing and then increasing
C. Brake specific fuel consumption 3. Increasing throughout the range
4. Decreasing throughout the range

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

Q9. Match List-I (Performance Parameter Y) with List-II (Curves labelled 1, 2, 3, 4 and 5 BHP vs. Y) regarding a C.I engine run at constant speed and select the correct answer using the codes given below the lists: [IES-2001]

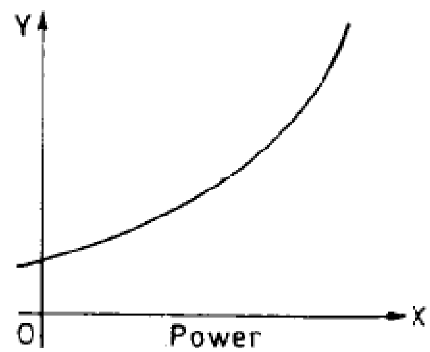
List-I
(Performance Parameter Y)
A. Total fuel consumption rate
B. Mechanical efficiency
C. Indicated power
D. Brake specific fuel consumption

List-II
(Curves BHP vs. Y)



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

Q10. The curve show in the given figure is characteristic of diesel engines. What does the Y-axis represent?
(a) Efficiency
(b) Specific fuel consumption
(c) Air-fuel ratio
(d) Total fuel consumption



[IES-1995]

Q11. Keeping other parameters constant brake power of a diesel engine can be increased by [IES-1995]
(a) decreasing the density of intake air
(b) increasing the temperature of intake air
(c) Increasing the pressure of intake air
(d) decreasing the pressure of intake air.

Q12. In the context of performance evaluation of I.C. Engine, match List I with List II and select the correct answer. [IES-1996]

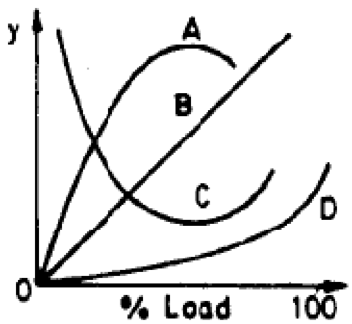
List I (Parameter)	List II (Equipment for measurement)
A. Brake power (B.H.P.)	1. Bomb calorimeter
B. Engine speed	2. Electrical tachometer
C. Calorific value of fuel	3. Hydraulic dynamometer
D. Exhaust emissions	4. Flame lonization detector

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

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

Q13. Match List I (performance curves, labelled A, B, C and D, for a constant speed diesel engine) with List II (performance parameter) and select the correct answer. [IES-1994]

List I



List II
1. Smoke level
2. Brake specific fuel consumption.
3. Brake thermal efficiency
4. Brake power

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

Q14. Which one of the following quantities is assumed constant for an internal combustion engine while estimating its friction power by extrapolation through Willan's line? [IES-1994]

(a) Brake thermal efficiency (b) Indicated thermal efficiency.
(c) Mechanical efficiency (d) Volumetric efficiency.

Q15. An engine produces 10 kW brake power while working with a brake thermal efficiency of 30%. If the calorific value of the fuel used is 40, 000 kJ/Kg, then what is the fuel consumption? [IES-2005]

(a) 1.5 kg/hour (b) 3.0 kg/hour (c) 0.3 kg/hour (d) 1.0 kg/hour

Q16. A 40 kW engine has a mechanical efficiency of 80%. If the frictional power is assumed to be constant with load, what is the approximate value of the mechanical efficiency at 50% of the rated load? [IES-2005]

(a) 45% (b) 55% (c) 65% (d) 75%

ANSWER WITH EXPLANATION

Previous Years GATE Answers

1. Ans. (c)

Given :

$$\text{B.P.} = 3037 \text{ kW}$$
$$(\text{I.P.})_1 = 3037 - 2102 = 935 \text{ kW}$$
$$(\text{I.P.})_2 = 3037 - 2102 = 935 \text{ kW}$$
$$(\text{I.P.})_3 = 3037 - 2100 = 937 \text{ kW}$$
$$(\text{I.P.})_4 = 3037 - 2098 = 939 \text{ kW}$$

Total I.P. of the cylinder $= (\text{I.P})_1 + (\text{I.P})_2 + (\text{I.P})_3 + (\text{I.P})_4$

$$= 935 + 935 + 937 + 939 = 3746 \text{ kW}$$

$\therefore$ Mechanical efficiency of the engine $= \dfrac{\text{B.P.}}{\text{I.P}} = \dfrac{3037}{3746} = 81.07\%$

2. Ans. (a)
3. Ans. (a)
4. Ans. (a)

Given, $\dfrac{\text{Fuel}}{\text{Air}} = 0.05$

$$\eta_{volumetric} = 90\%$$
$$\eta_{thermal} = 30\%$$
$$\text{Calorific value} = 45 \text{ MJ/kg}$$
$$\frac{m_f}{m_a} = 0.05$$
$$\rho_{air} = 1 \text{ kg/m}^3$$

Volumetric efficiency, $\eta_V = \dfrac{\text{actual volume}}{\text{swept volume}} = \dfrac{V_{ac}}{V_s}$

$\therefore$

$$V_{ac} = 0.9\, V_s$$
$$m_a = \rho_{air} V_{ac}$$
$$= 1 \times 0.9 \times V_s$$
$$= 0.9\, V_s$$
$$m_f = 0.05 \times 0.9\, V_s$$
$$= 3.045\, V_s$$
$$\eta_{thermal} = \frac{p_{mep} \times \text{LAN}}{m_f \times \text{C.V}}$$
$$0.3 = \frac{p_{mep} \times V_s}{0.0215 V_s \times 45 \times 10^6} \quad \text{..... since LAN} = V_s$$
$$p_{mep} = 0.3 \times 0.045 \times 45 \times 106$$
$$= 6.075 \text{ bar.}$$

Previous Years IES Answers

1. Ans. (c) The torque developed by an engine is directly proportional to the indicated power. Thus maximum torque will occur corresponding to maximum indicated power.

2. Ans. (a) Indicated power of second cylinder is 9 - 4.25 = 4.75 kW and of first engine is 9 - 3.75 = 5.25 kW.

Thus total indicated power of engine is 4.75 + 5.25 = 10 kW.

:. Mechanical efficiency of engine $= \dfrac{9}{10} \times 100 = 90\%$

3. Ans. (d) The performance of S.I. engine can't be improved by increasing the compression ratio because of pre-ignition and detonation.

Since high octane number tends to suppress detonation, t6 some extent fuels of higher octane number will be helpful at higher compression ratio.

4. Ans. (c) Indicated power is concerned with P_mLAN, i.e. mean effective pressure, length of stroke, piston diameters and speed of rotation.

5. Ans. (a) Morse test is used to determine indicated power of multi-cylinder S.I. engine

6. Ans. (a)

7. Ans. (a) For higher thermal efficiency, the mixture strength should be little leaner than stoichiometric

8. Ans. (d)

9. Ans. (a)

10. Ans. (d) Y-axis represents total fuel consumption.

11. Ans. (c) Brake power of diesel engine can be increased by increasing pressure of intake air. Supercharging.

12. Ans. (c)

13. Ans. (b)

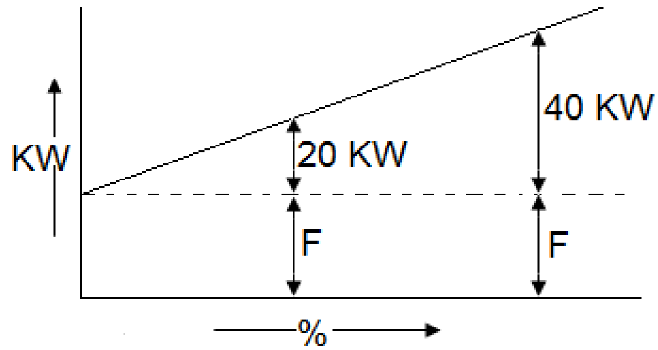
14. Ans. (b)

15. Ans. (b) $\eta_{bt} = \frac{B.P.}{\dot{m}_f.(cv)_f}$ or $\dot{m}_f \times 3600 = \frac{B.P \times 3600}{\eta_{bt} \times (cv)_f} = \frac{10 \times 3600}{0.3 \times 40000} = 3kg/hr$

16. Ans. (c)

$$0.8 = \frac{40}{40+F} \text{ or } F = 10kW$$

$$\therefore \eta = \frac{20}{20+10} = 67\%$$



Conventional Questions with Answers

Q1. **A four stroke diesel engine of 3000 cc capacity develops 14 kW per m³ of free air induced per minute. When running at 3500 rev/min it has a volumetric efficiency of 85 per cent referred to free air-conditions of 1.013 bar and 27°C . It is proposed to boost the power of the engine by supercharging by a blower (driven mechanically from the engine) of pressure ratio 1.7 and isentropic efficiency of 80 per cent. Assuming that at the end of induction the cylinders contain a volume of charge equal to the swept volume, at the pressure and temperature of the delivery from the blower, estimate the increase in bp to be expected from the engine. Take overall mechanical efficiency as 80 per cent. r for air = 1.4, R = 0.287 kJ/kg K.**

[IES-2009, -13-Marks]

Ans. Swept volume, V_S

$$= 3000 \times 10^{-6} \times \frac{3500}{2}$$

$$= 5.25 \text{ m}^3/\text{min}$$

Actual volume of air Inducted $V_a = V_S \times$ Volumetric efficiency (η_v)

$$= V_S \times \eta_v$$

$$= 5.25 \times 0.85$$

$$= 4.4625 \text{ m}^3/\text{min}$$

$$= 4.4625 \times 14$$

$$= 62.475 \text{ kW}$$

Delivered pressure from the compressor,

$$p_a = 1.013 \times 1.7 = 1.7221 \text{ bar}$$

Assuming isentropic compressor, we have

$$\frac{T_d}{T_a} = \left(\frac{p_d}{p_a}\right)^{\frac{\gamma-1}{\gamma}} = (1.7)^{\frac{0.4}{1.4}}$$

$$T_d = T_a (1.7)^{\frac{0.4}{1.4}} = 300(1.7)^{0.287}$$

$$= 349.349 \text{ K}$$

Isentropic efficiency of the compressor

$$\eta_c = \frac{\text{Isentropic temperature rise}}{\text{Actual temperature rise}}$$

$$= \frac{\Delta T_S}{\Delta T_{ac}}$$

$$\therefore\ 0.8 = \frac{349.349 - 300}{T_{ac} - 300}$$

$$\Rightarrow\ T_{ac} = 361.68 \text{ K}$$

Actual volume of air induced corresponding to swept volume at atmospheric condition by the engine

$$= \frac{5.25 \times 1.7221 \times 300}{1.013 \times 361.68}$$

$$= 7.403 \text{ m}^3/\text{min}$$

So increase intake volume of air

$$= 7.403 - 5.25 = 2.153 \text{ m}^3/\text{min}$$

Increase in input pressure due to supercharging

= 2.153 × 14 = 30.14 kW

Increase in input pressure due to increase in intake pressure because of supercharging

$$= \frac{\Delta p \times V_S}{60 \times 1000}$$

$$= \frac{(1.7-1) \times 1.013 \times 10^5 \times 5.25}{60 \times 1000}$$

$$= \mathbf{6.204\ kW}$$

Total increase in input pressure

= 30.14 + 6.204

= 36.344 kW

Increase in bp

= Mechanical efficiency × input pressure

= 0.8 × 36.344 = 29.0752 kW

Q2. The following data are known for a four cylinder four stroke petrol engine: cylinder dimensions: 11 cm bore, 13 cm stroke; engine speed : 2250 rpm; brake power: 50 kW; friction power : 15 kW; fuel consumption rate: 10.5 kg/h; calorific value of fuel: 50,000 kJ/kg; air inhalation rate: 300 kg/h; ambient condition : 15°C, 1.03 bar.

Estimate

(i) brake mean effective pressure

(ii) Volumetric efficiency

(iii) Brake thermal efficiency, and

(iv) Mechanical efficiency. [IES-2008, 10-Marks]

Ans. Given,

D = Cylinder bore = 11 cm

L = Length of stroke = 13 cm

N = rpm of engine = 2250

B.P. = 50 kW

Friction power = $f_p = 15$ **kW**

Fuel consumption rate = $\dot{m}_f = 10.5$ **kg/hr**

Colorific value of fuel = CV = 50000 kJ/kg

Air inhalation rate = $\dot{m}_a = 300$ **kg/hr**

Ambient condition, P = 1.03 bar,

$$T_{amb} = 15°C = 288\ K$$

(i) Now, Swept volume, V_s

$$= \frac{\pi}{4} D^2 L$$

$$= \frac{\pi}{4} (11)^2 (13) \times 10^{-6} m^3$$

$$= \mathbf{0.001235\ m^3}$$

∴ Total swept volume for 4 cylinder = 4 × 0.001235 m^3

But b.p. = $\frac{P_{bm} LAnK}{60000}$

where,

P_{bm} **= brake mean effective pressure**

$n = \frac{N}{2}$ **for 4- stroke engine**

K = number of cylinder = 4(given)

$$\therefore\ P_{bm} = \frac{bp \times 60000}{LAn\,K}$$

$$= \frac{50 \times 60000}{13 \times 10^{-2} \times \frac{\pi}{4}(11)^2 \times 10^{-4} \times \frac{2250}{2} \times 4}\ N/m^2$$

$$= 5.396 \times 10^{-4} \times 10^{6} \times 10^{3}$$

$$= 5.396 \times 10^{5}\ N/m^2$$

$$= 5.396\ bar$$

(ii) $\because$ **swept volume per minute,**

$$\dot{V}_s = \frac{\pi}{4}\ D^2\,LnK$$

$$= 4 \times 0.001235 \times \frac{2250}{2}$$

$$= 5.558\ m^3/min$$

Again, $\dot{m}_a = 300\ kg/hr$

$$= \frac{300}{60} kg / min = 5kg / min.$$

$\therefore$ volume flow rate of air at intake condition,

$$\dot{V}_a = \frac{m_a RI}{P} = \frac{5 \times 287 \times 288}{1.03 \times 10^5}$$

$$= 4.0124\ m^3 / min$$

$\therefore$ **volumetric efficiency**

$$= \eta_v$$

$$= \frac{\dot{V}_a}{\text{swept volume/min}}$$

$$= \frac{4.0124}{5.558} = 72.19\%$$

(iii) Brake thermal efficiency,

$$\eta_{bth} = \frac{bp}{\dot{m}_f \times CV}$$

$$= \frac{50}{\frac{10.5}{3600} \times 5000}$$

$$= \frac{50 \times 3600}{10.5 \times 50000}$$

$$= 34.29\%$$

(iv) Since bp = 50 kW

fp = 15 kW

ip = bp + fp = 65 kW

$\therefore$ **mechanical efficiency,**

$$\eta_m = \frac{bp}{ip} = \frac{50}{65} = 76.92\%$$

8. Engine Cooling

OBJECTIVE QUESTIONS (IES)

Previous Years IES Questions

Q1. **Assertion (A):** Cooling system in an IC engine must be such that there is no excessive cooling.
Reason (R): Overcooling would result in increased viscosity of the lubricant due to which the overall efficiency of the engine will decrease. **[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

Q2. **Consider the following statements in respect of automobile engine with thermo-syphon cooling:** **[IES-2003]**
1. Heat transfer from gases to cylinder walls takes place by convection and radiation.
2. Most of the heat transfer from radiator to atmosphere takes place by radiation.
3. Most amount of heat transfer from radiator to atmosphere takes place by convection.
4. Heat transfer from cylinder walls takes place by conduction and convection.
Which of the above statements are correct?
(a) 1, 2 and 4 (b) 1, 3 and 4 (c) 2, 3 and 4 (d) 1 and 2

ANSWER WITH EXPLANATION

Previous Years IES Answers

1. Ans. (c) Disadvantages of overcooling:

- At too low engine temperatures starting may be difficult and above all,
- The low temperature corrosion assumes such a significant magnitude that the engine life is greatly reduced.
- At low temperatures, the sulphurous and sulphuric acids resulting from combustion of fuel (fuel always contains some sulphur) attack the cylinder barrel.
- The dew points of these acids vary with pressure and hence the critical temperature, at which corrosion. Assumes significant proportions, varies along the cylinder barrel.
- To avoid condensation of acids the coolant temperature should be greater than 70°C.
- The cooling system should not only cool but must also keep the cylinder liner temperature above a minimum level to avoid corrosion and ensure good warm up performance of the engine

2. Ans. (c)

9. Emission & Control

OBJECTIVE QUESTIONS (GATE, IES & IAS)

Previous Years GATE Questions

Q1. Global warming is caused by **[GATE-2000]**
(a) Ozone (b) carbon dioxide
(c) Nitrogen (d) carbon monoxide

Q2. The silencer of an internal combustion engine **[GATE-1999]**
(a) Reduces noise (b) decrease brake specific fuel consumption (BSFC)
(c) Increase BSFC (d) has no effect on its efficiency

Previous Years IES Questions

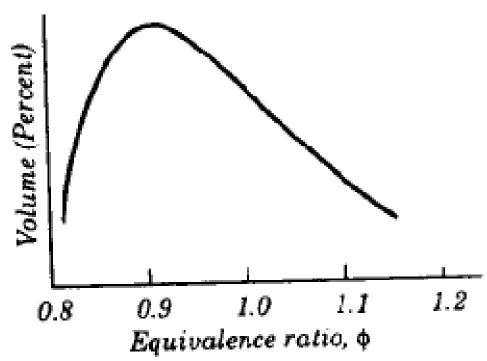
Q1. Which one of the following set of materials is most commonly used in catalytic converters for CI engines? **[IES-2008]**
(a) Platinum, palladium and rhodium
(b) Palladium, rhodium and ruthenium
(c) Rhodium, ruthenium and platinum
(d) Ruthenium, platinum and palladium

Q2. The three way catalytic converter cannot control which one of the following?
(a) HC emission (b) CO emission **[IES-2008]**
(c) NO_x emission (d) PM emission

Q3. Which one of the following cannot be controlled by a three-way catalytic converter?
(a) HC emission (b) CO emission
(c) NO_x emission (d) SPM emission **[IES-2005]**

Q4. Which of the following symptoms shows that the combustion is necessarily complete? **[IES-2009]**
(a) Presence of free carbon in exhaust (b) Presence of CO in exhaust
(c) Presence of oxygen in exhaust (d) Presence of nitrogen in exhaust

Q5. The graph shown in the given figure represents the emission of a pollutant from an SI engine for different fuel/air ratios. The pollutant in question is
(a) CO
(b) CO_2
(c) hydrocarbons
(d) NO_x



[IES-

1998]

Q6. With respect to I.C. engine emissions, consider the following statements:
1. Evaporative emissions have no carbon monoxide and oxides of nitrogen.
2. Blow by emissions is essentially carbon monoxide and suspended particulate matter. **[IES-2001]**
3. Exhaust emissions contain 100% of carbon monoxide, 100% of oxides of nitrogen and around 50-55% of hydrocarbons emitted by the engine.
4. There are no suspended particulates in the exhaust.
Of these statements are correct
(a) 1 and 4 (b) 1 and 3 (c) 2 and 3 (d) 1, 2, 3, and 4

Q7. Which one of the following automobile exhaust gas pollutants is a major cause of photochemical smog?
(a) CO (b) HC (c) NO_x (d) SO_x **[IES 2007]**

Q8. Consider the following emissions of an IC engine: **[IES-1999]**
1. CO_2 2. HC 3. NO_x 4. Particulates
Which of these emissions cause photochemical smog?
(a) 1 and 4 (b) 1 and 2 (c) 2 and 3 (d) 3 and 4

Q9. The presence of nitrogen in the products of combustion ensures that:
(a) Complete combustion of fuel takes place **[IES-1997]**
(b) Incomplete combustion of fuel occurs
(c) Dry products of combustion are analyzed
(d) Air is used for the combustion

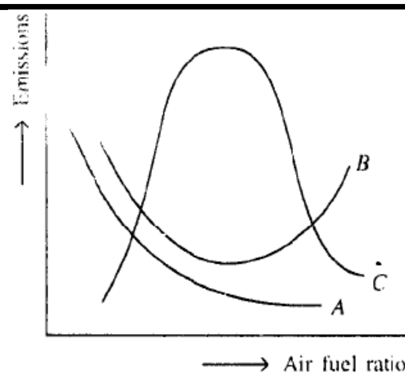
Q10. Consider the following statements: **[IES-2004]**
Exhaust emissions of carbon monoxide from spark ignition engine is
1. **mainly fuel-air mixture strength dependent**
2. **in the range of zero to 10%**
3. **measured with the help of an instrument working on the principle of non-dispersive infra-red analysis**
4. **controlled by the use of a two way catalytic convertor**

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

Q11. An engine using octane-air mixture has N_2, O_2, CO_2, CO and H_2O as constituents in the exhaust gas. Which one of the following can be concluded?
(a) Supply mixture is stoichiometric **[IES-2004]**
(b) Supply mixture has incomplete combustion
(c) Supply mixture is rich
(d) Supply mixture is lean

Q12. Which of the following factors are responsible formation of NO, in spark ignition engine combustion: **[IES-1996]**
1. Incomplete combustion
2. High temperature
3. Availability of oxygen.
Select the correct answer.
(a) 2 and 3 (b) 1 and 2 (c) 1 and 3 (d) 1, 2 and 3

Q13. Exhaust emissions vs air fuel ratio curves for a petrol engine are shown in the given figure. The curve C represents



(a) Hydro carbon
(b) Carbon dioxide
(c) Carbon monoxide
(d) Oxides of nitrogen

[IES-2003]

Q14. The discharge of hydrocarbons from petrol automobile exhaust is minimum when the vehicle is: **[IES-2005]**
(a) Idling (b) Cruising (c) Accelerating (d) Decelerating

Q15. Consider the following statements for NO_x emissions from I.C. engines:
1. **Formation of NO_x depends upon combustion temperature** **[IES-2004]**
2. **Formation of NO_x depends upon type of coolant used**
3. **Exhaust gas recirculation is an effective means for control of NO_x**
4. **Activated Platinum is used for reduction of NO_x**

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

Q16. Assertion (A): Catalytic converters for reduction of oxides of nitrogen in engine exhaust cannot be used with leaded fuels. **[IES-2000]**
Reason (R): Catalyst will be removed due to chemical corrosion by lead salts.
(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

Q17. Assertion (A): In Infrared gas analyser, the amount of absorption is the function of concentration of the gas and the length of the absorption path. **[IES-1999]**
Reason (R): Different gases are characterized by distinctive absorption bands within the infrared range.
(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

Previous Years IAS Questions

Q1. Which of the following symptoms show that the combustion in air is necessarily complete?
(a) Absence of Oxygen in exhaust
(b) Absence of Nitrogen in exhaust **[IAS-2002]**
(c) Absence of free carbon in exhaust
(d) Absence of carbon monoxide in exhaust

ANSWER WITH EXPLANATION

Previous Years GATE Answers

1. Ans. (b) carbon di-oxide acts as thermal shield to atmosphere.
2. Ans. (a)

Previous Years IES Answers

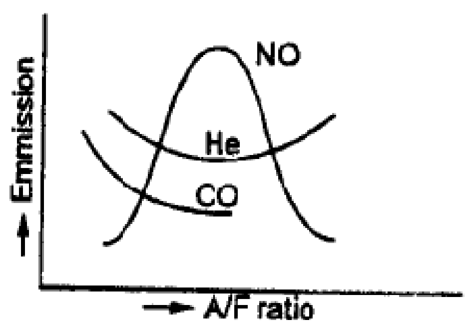
1. Ans.(a)
2. Ans. (d)

3-way catalytic converter

Palladium → CO
Rhodium → NO_X
Platinum → HC

3-way catalytic converter consist platinum (Pt), palladium (Pd) and Rhodium (Rb). Rhodium first convert NOX into N_2 and O_2. Platinum convert hydrocarbon (HC) into H_2O and CO_2. Palladium convert CO (carbon mono-oxide) into CO_2. It has a honey comb structure.

3. Ans. (d)
4. Ans. (c)
5. Ans. (d) Maximum temperature is produced at slightly rich air mixture and NO_x emission is proportional to temperature.
6. Ans. (c) Evaporative emissions account for 15 to 25 per cent of total hydrocarbon emission from a gasoline engine. The two main sources of evaporative emissions are the fuel tank and the carburettor.
7. Ans. (c) In bright sunlight (i) NO_x, (ii) HC, (iii) O_2 intact chemically to produce powerful oxidants like ozone (O_3) and peroxyacetylnitrate (PAN). It is photochemical smog.
8. Ans. (c)
9. Ans. (d) Nitrogen in flue gas means air is used for combustion
10. Ans. (d)
11. Ans. (b)
12. Ans. (a) NO_x is formed due to incomplete combustion and at high temperature.
13. Ans. (d)



14. Ans. (b)
15. Ans. (b)
16. Ans. (c) Catalytic converters requires a non-leaded fuel because the lead compound, along with its scavengers, affects the performance of the catalysts.
17. Ans. (a)

Previous Years IAS Answers

1. Ans. (d)