Preface

We take immense pleasure in presenting you the comprehensive book containing all the questions that has been asked in GATE examination. This will help you in preparing for different exams such as GATE, ICAR JRF/SRF, ARS,, State Engineering Exams, Maharashtra Agriculture Service, IBPS AFO & IFS.

This book is written by Sagar Khurana, an alumni of IISc (Indian Institute of Science), Bangalore with a vision to provide quality examination content for Agriculture Engineering students. It comprises of

If you have any query, please write to us at enquirygateforall@gmail.com

Wishing You All the Best
GateForAll

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CONTENTS

Chapter 5 *Human Factors*

$$Sound\ (unit) = Decibel\ (Db)$$

85 db → $(The\ upper\ safe\ noise\ level)$

90 db → $Maximum\ noise\ level\ near\ operoter\ rear$

115 db → $(Pain)(start)$

Human :-

$Indiuiduals\ comfartable\ Temp - (24° - 27°)$

$Vibration\ human\ tolerance - (4 - 8)Htz$

$body\ surfce\ area\ of\ a\ man = 2m^2$

SPL ($Sound\ Pressure\ level$)

$$standard\ reference\ sound\ Pressure$$

$$20\mu Pa\ \ (2 \times 10^{-5})Pascal$$

$$Temp = 20°\ Degree$$

$$(Refernce\ Pressure)$$

SPL

20	$2 \times 10^{-5}\ Pascal$
$10^{(f(x))}$	$P \uparrow$

Sound Pressure level :-

$$SPL = 20\log_{10}\frac{P_{rms}}{P_0} = dB$$

$P_0 = reference\ sound\ Pressure$

$$\boxed{P_0 = 2\times 10^{-5}\ N/m^2}$$

$SPL = dB$

$P_0 = 1\,N/m^2$	$SPL = dBA$

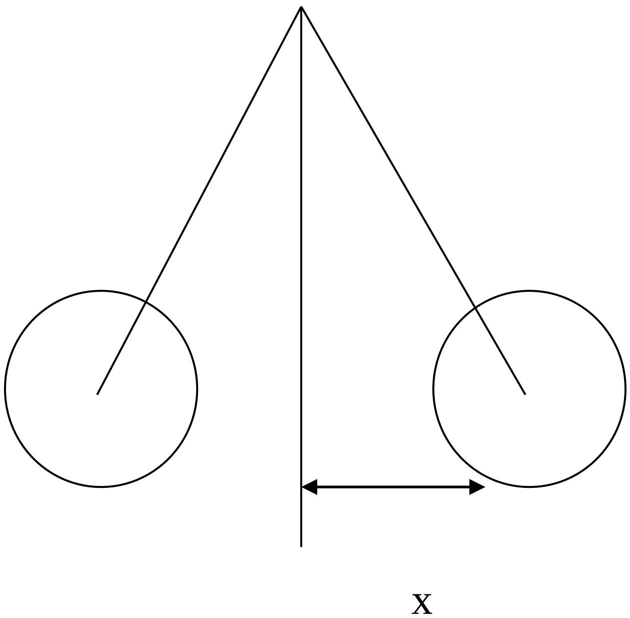
Variable Acceleration level :-

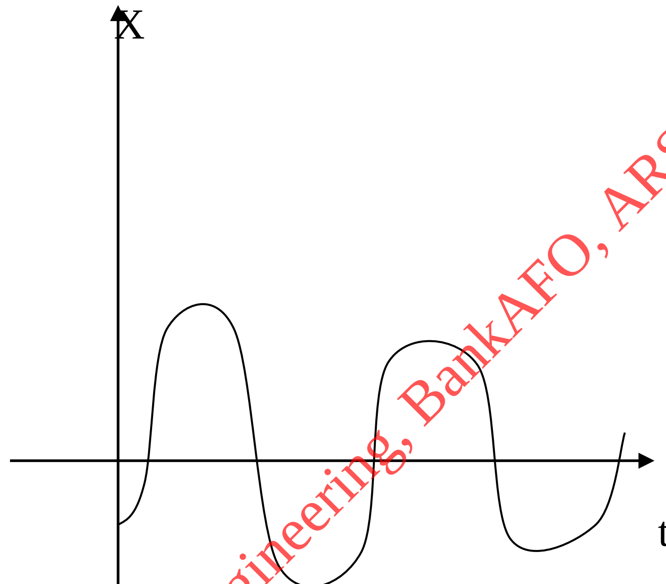
$$VAL = 2\log_{10}\left(\frac{V}{V_0}\right) \qquad dB$$

$V = measured\ Rms\ acceleration$

$V_0 = reference\ acceleration$

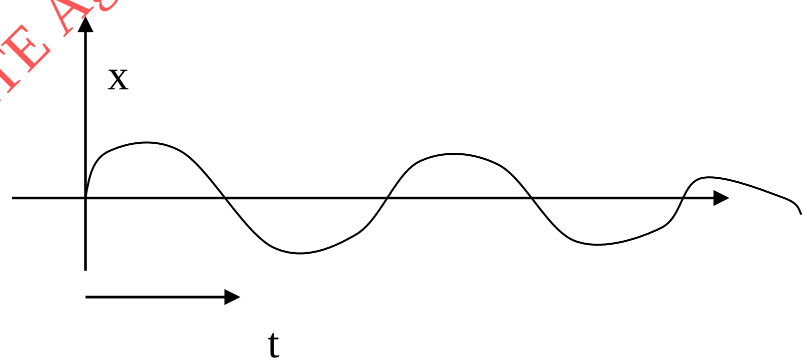
Damping



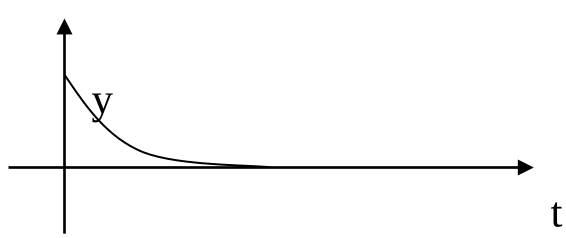


Damping:- *Amplitude become zero*

Under domping



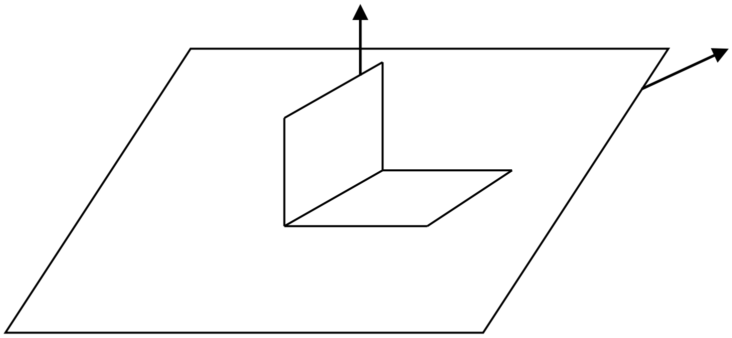
Critical domping



$$Damping\ ratio = \in = \frac{Under\ domping}{critical\ domping}$$

$\underline{Transmissibillity}$

$$T = \frac{output\ Vibration\ Intensity}{Input\ Vibration\ intensity}$$



$\underline{\mu_s[Rrequency\ of\ Seat]}$

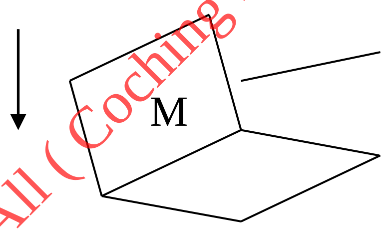
$$w_s = \sqrt{\frac{k}{m}}$$

$k = spning\ constant$

$m = (mass\ of\ seat + operater)$

$k(spning\ constant)$

$$M\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = 0$$



$T = 2\pi\sqrt{\frac{m}{k}}$

$$w = \frac{T}{2\pi} = \sqrt{\frac{m}{k}}$$

$$T = \left[\frac{1 + \left[2 \in \left(\frac{wt}{ws}\right)\right]^2}{\left[1 - \left(\frac{wt}{ws}\right)^2\right]^2 + \left(2 \in \frac{wt}{ws}\right)^2}\right]^{0.5}$$

$\in = domping\ ratio$

$w_t = frequency\ of\ tractor$

$w_s = frequency\ of\ seat$

$w_s = \sqrt{\frac{k}{m}}$ $k = spring\ constant$

$m = operter + seat$

$$\in = \frac{C[seat\ domping]}{C_c[Critical\ domping]}$$

$C_c = 2\ mw_s$

$w_s[frequency\ of\ seat]$

$$w_s = \sqrt{\frac{k}{m}}$$

¼$\underline{Frequency\ of\ seat}$ de gS½

$\underline{Critical\ domping\ rate\ (C_c)}$

$C_c = 2.m.w_s$

$$T = \left[\frac{1 + 4\in^2\left(\frac{wt}{ws}\right)^2}{\left[1 - \left(\frac{wt}{ws}\right)^2\right]^2 + 4\in^2\left(\frac{wt}{ws}\right)^2}\right]^{0.5}$$

$\in = domping\ rtio$

$$\in = \frac{Seat\ suspenson\ domping\ rate}{Critical\ domping\ rate}$$

Numerical

Q1. Sound was measured at 80 DBA and 76dBA in the operator's cabin on a tractor. What is the RMS sound pressures correspond to both the sound pressure level [GATE 1998]

Q2. Sound was measured at 80 DB in the operator's cabin on a tractor. What is the RMS sound pressure and also determine the resultant sound pressure in decibels, if the sound pressure is increased eight times [GATE 2001]

Q3. The measures value of the acceleration at the cab floor of the tractor is 2 m/ s^2. If the ratio of the frequency of the tractor chassis and the under amped natural frequency of the set is 2 and the damping ratio is zero. Find out the vibration intensity experienced by the operator (A) 0.4 M /S^2 (B) 0.66 M /S^2 (C) 0.88 M /S^2 (D) 1.16 M /S^2 [GATE2006]

Q4. The differential equation of motion for a single degree of freedom mass-spring damped system is 8 $\frac{D^2x}{Dt^2} + 5\frac{Dx}{Dt} + 12t = 0$ .If the units of mass, length and time are Kg, m and sec respectively. The natural frequency of the vibration is in

(A) 0.42 rad /sec (B) 0.52 rad /sec (C) 1.22 rad /sec (D) 1.83 rad /sec [GATE2006]

Q5. A tractor seat suspension system with a seat and operator mass of 90 kg has a seat suspension damping rate of 350 N s m-1. If the spring rate of the system is 5 N mm 1, the damping ratio of the system is [GATE 2009]

(A) 0.13 (B) 0.26 (C) 0.39 (D) 0.52

Q6. The tractor seat vibrates with a frequency of 1 Hz when there is no damping, when damping is provided the frequency of damped vibration is reduced by 10%. The damping factor is [GATE 2010]

(A) 0.21 (B) 0.39 (C.) 0.4-4 (D) 0.93

Q7. The range of frequency of vertical vibration of tractor most harmful to the operator's body at a root mean square acceleration of 1.0 m –s-2 in Hertz [GATE 2011]

(A) 0.4 — 0.8 (B) 4.0 — 8.0 (C) 400 — 800 (D) 4000 — 8000

Q8. During a test, sound level was measured as 90 dB in the operator’s cabin on a tractor. Taking reference sound pressure as 2□10□5 N m-2, the measured RMS sound pressure in N m/Sec^2 is [GATE 2013]

(A) 6.32 (B) $6.32*10^{-1}$ (C) $1.8*10^{-3}$ (D) $6.32*10^{-10}$

Q9. For a reference sound pressure of 2×10-5 N m-2, the sound level measured at the operator’s workspace of a tractor was 80 dB. If the RMS sound pressure is increased by eight times, the resulting sound pressure level in dB, will be ______. [GATE 2015]

Q10. Natural frequency of an undamped operator seat is 5 Hz, and combined weight of the seat and the operator is 880 N. If there are four springs fitted in parallel below the operator seat, the spring rate (or stiffness) of each spring in kN m-1 is ____________ [GATE 20

$Q.1 \rightarrow$ GATE 1998

$SPL = 84\ dBA$

$SPL = 20\log_{10}\left(\frac{P}{1}\right)$

$\frac{84}{20} = \log_{10} P$

$P = 15848.931912\ Pascal$

$SPL = 76\ DBA$

$SPL = 20\log_{10}\left(\frac{P}{P_0}\right)$

$if\ DBA \qquad P_0 = 1$

$76 = 20\log_{10}\left(\frac{P}{P_0}\right)$

$P_2 = 6309\ N/m^2$

$Q.2 \rightarrow$ GATE 2001

$$SPL = 20\log\left(\frac{P}{P_0}\right)$$

$$SPL = 80\ DB$$

$$P_0 = 2 \times 10^{-5}\ N/m^2$$

$$SPL = 20\log_{10}\left(\frac{P}{2 \times 10^{-5}}\right)$$

$$80 = 20\log_{10}\left(\frac{P}{2 \times 10^{-5}}\right)$$

$$\frac{80}{20} = \log_{10}\left(\frac{P}{2 \times 10^{-5}}\right)$$

$$10^4 \times 2 \times 10^{-5} = P$$

$$P = 0.2\ N/m^2$$

GATE 2001

$SPL = ?$

$P = 0.2 \times 8$

$P = 1.6\ N/m^2$

$$SPL = 20 \log_{10}\left(\frac{1.6}{2 \times 10^{-5}}\right)$$

$= 98\ db$

$SPL = 98\ db$

$Q.3 \rightarrow$ GATE 2006

$\alpha = 2\, m/sec$

$\in = 0$

$\frac{wt}{ws} = 2$

$$T = \left[\frac{1 + 4 \in^2 \left(\frac{wt}{ws}\right)^2}{\left[1 - \left(\frac{wt}{ws}\right)^2\right]^2 + 4 \in^2 \left(\frac{wt}{ws}\right)^2}\right]^{0.5}$$

$$T = \left[\frac{1}{\left[1 - \left(\frac{wt}{ws}\right)^2\right]^2}\right]^{0.5}$$

$$T = \frac{1}{1 - (2)^2} = \left(\frac{1}{9}\right)^{0.5}$$

$$T = \frac{1}{3} = \frac{output\ Intensity}{2}$$

$$output = \frac{2}{3} = 0.66\, m/sec^2$$

$Q.4 \rightarrow$ GATE 2008

$$8\frac{d^2x}{dt^2} + 5\frac{dx}{dt} + 12x = 0$$

$$w_s = \sqrt{\frac{k}{m}}$$

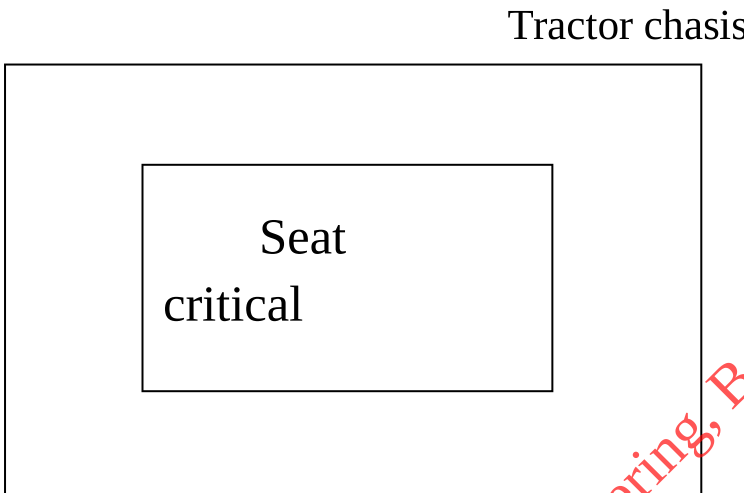
$$w_s = \sqrt{\frac{k}{m}}$$

$k = 12$

$m = 8$

$w_x = \sqrt{\frac{12}{8}} = 0.22\, rad/sec$

$Q.5 \rightarrow$ GATE 2009



$$\in = \frac{C_s}{C_c} = \frac{Seat\ domping\ rate}{Critical\ domping\ rate}$$

$C_c = 2\ mw_x$ $\qquad C_s = 350$

$= 2m\sqrt{\frac{k}{m}}$ $\qquad m = 20$

$C_c = 2\sqrt{90 \times 5000}$ $\qquad k = 5\ N/mm$

$C_c = 1341\frac{N-s}{m}$ $\qquad k = 5\ N/10^{-3} \quad k = 5000$

$$\in = \frac{350}{1341} = 0.26$$

$Q.6 \rightarrow$ GATE 2010

$$\epsilon = \sqrt{1 - \left(\frac{wt_{domping}}{ws_{seat}}\right)^2}$$

$$\epsilon = \sqrt{\left(1 - \frac{(0.9)^2}{1}\right)}$$

$$= \sqrt{1 - 0.81}$$

$$= \sqrt{0.19}$$

$$\epsilon = 0.43$$

$Q.8 \rightarrow$ GATE 2013

Human factors

$$SPL = 90dB$$

$$SPL = 20\log\left(\frac{P_{rms}}{P_0}\right)$$

$$90 = 20\log_{10}\left(\frac{P}{P_0}\right)$$

$$\frac{90}{20} = \log_{10}\left(\frac{P}{P_0}\right)$$

$$P_0 = 2 \times 10^{-5}$$

$$P = 31622 \times 10^{-5} \times 2$$

$$P = 6.32\ N/m^2 \times 10^{-1}$$

$$P = 6.32 \times 10^{-1}\ N/m^2$$

$Q.9 \rightarrow$ GATE 2016

$m_{s+o} = 880\ N$

$f = 5Ht_3$

$$w_s = \sqrt{\frac{k}{m}}$$

$$2\pi f = \sqrt{\frac{k}{m}}$$ $k \rightarrow N/m$

$$2\pi \times 5 = \sqrt{\frac{k^1}{m}}$$ $m \rightarrow kg$

$$m = \frac{880}{9.8} = 89.79\ kg$$

$$2\pi \times 5 = \sqrt{\frac{k^1}{89.79}}$$

$k^1 = 88.619$

$$k_{each\ spring} = \frac{k^1}{4} = 22154\ N/m'$$

$k_{each} = 22.54\ KN/m$

$Q.10 \rightarrow$ GATE 2015

$$SPL = 20\log_{10}\left(\frac{P}{P_0}\right)$$

$$80 = 20\log_{10}\left(\frac{P}{2\times10^{-5}}\right)$$

$$P = 0.2$$

$$P_{new} = 8\times0.2 = 1.6$$

$$SPL_{new} = \log_{10}\left(\frac{1.6}{2\times10^{-5}}\right)$$

$$SPL_{new} = 98.06\ dB$$