CLASS TEST

S.No.:01DLSKME_ABCDEFGH_28826

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THEORY OF MACHINES

MECHANICAL ENGINEERING

Date of Test : 28/08/2026

ANSWER KEY

1.	(b)	7.	(b)	13.	(c)	19.	(a)	25.	(c)
2.	(d)	8.	(a)	14.	(b)	20.	(c)	26.	(c)
3.	(c)	9.	(b)	15.	(a)	21.	(b)	27.	(b)
4.	(b)	10.	(b)	16.	(c)	22.	(c)	28.	(b)
5.	(b)	11.	(b)	17.	(a)	23.	(c)	29.	(c)
6.	(b)	12.	(b)	18.	(d)	24.	(b)	30.	(c)

DETAILED EXPLANATIONS

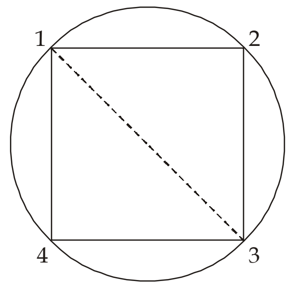
1. **(b)**

$$\text{Velocity ratio} = \frac{\text{Product of number of teeth on driven}}{\text{Product of number of teeth on driver}}$$

2. **(d)**

Total number of links are '4'

So, I_{13} will lie on intersection of I_{12} I_{23} and I_{14} I_{43}.

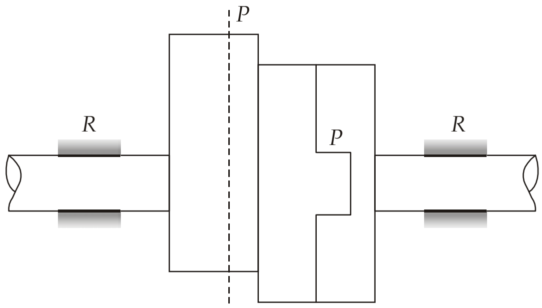


Here, I_{12} is at D,
I_{23} is at C
I_{14} is at A
and I_{43} is at ∞ ($\perp$ link AB)

Hence, I_{13} will be at 'K'.

3. **(c)**

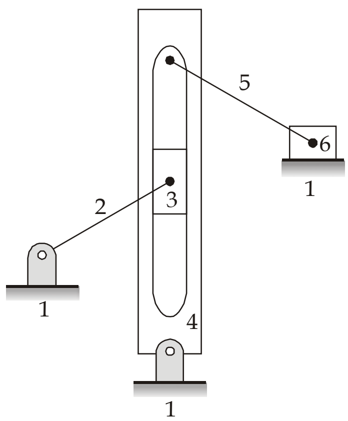
Oldham's coupling:



Here, R = Revolute joint
P = Prinsmatic joint

Oldham's coupling has two revolute and two prismatic joints and also R-R and P-P are together (Not alternative as in option (b)). Hence option (c) is correct.

4. **(b)**



Number of link, n = 6

Number of lower pair, (j)

$$\left.\begin{array}{l}\text{Sliding pair} = 2\\ \text{Revolute pair} = 5\end{array}\right\} j = 7$$

$$\text{DOF} = 3(n-1) - 2j - h = 3(5) - 2 \times 7 = 1$$

5. (b)

$\Sigma F_x = 0$

$m_p r_p \cos\theta_p + m_Q r_Q \cos\theta_Q + m_R r_R \cos\theta_R + m_S r_S \cos\theta_S = 0$

$\Rightarrow 0.8 \cos 0 + 0.6 \cos 90° + 0.6 \cos 140° + 0.12\, m_S \cos\theta_S = 0$

$$m_S \cos\theta_S = -2.836$$

Put, $\theta_S = 180° + 70.95° = 250.95°$

On solving: $m_S = 8.688$ kg

6. (b)

Gyroscopic couple, $C = I\omega\omega_p$

Here, $120 = 3 \times 20 \times \omega_p$

$\Rightarrow \omega_p = 2$ rad/s

7. (b)

The liquid column is displaced from equilibrium position by a distance x. If ρ and A are the mass density of liquid and cross section area of tube.

Mass of the liquid column $= \rho AL$

$$\text{Kinetic energy, K.E.} = \frac{1}{2}(\rho AL)\dot{x}^2$$

$$\text{Potential energy, P.E.} = (\rho Ax)gx = \rho Agx^2$$

$$\text{Total energy, } T = \frac{1}{2}(\rho AL)\dot{x}^2 + \rho Agx^2$$

$$\frac{dT}{dt} = 0 \qquad \text{(From energy method)}$$

$$\Rightarrow \rho AL\dot{x}\ddot{x} + 2\rho Agx\dot{x} = 0$$

$$L\ddot{x} + 2gx = 0$$

$$\omega_n = \sqrt{\frac{2g}{L}} \text{ rad/s}$$

8. (a)

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$12 = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \qquad \text{...(i)}$$

$$6 = \frac{1}{2\pi}\sqrt{\frac{k-800}{m}} \qquad \text{...(ii)}$$

Divide equation (i) by equation (ii),

$$2 = \sqrt{\frac{k}{k-800}}$$

$$\frac{k}{k-800} = 4$$

$$\Rightarrow 3k = 3200,\ k = \frac{3200}{3}$$

9. (b)

$$k = 2\left(\frac{a}{b}\right)^2\left(\frac{F_1 - F_2}{r_1 - r_2}\right)$$

$$k = 2(1)^2\left(\frac{2000 - 100}{30 - 20}\right)$$

$$k = 2\times\left(\frac{1900}{10}\right) = 380 \text{ N/cm}$$

10. (b)

Given:

$$m_B = 1.5 \text{ kg}$$

$$m_A = ?$$

$$\omega = \frac{2\pi}{T}$$

or $$T = \frac{2\pi}{\omega}$$

When both cylinders A and B are connected

$$\therefore \quad T_1 = 2\pi\sqrt{\frac{m_A + m_B}{k}}$$

When cylinder A is connected

$$T_2 = 2\pi\sqrt{\frac{m_A}{k}}$$

then, $$\frac{T_1}{T_2} = \frac{\sqrt{m_A + m_B}}{\sqrt{m_A}}$$

$$\therefore \quad \left\{\frac{0.6}{0.5}\right\}^2 = \frac{m_A + 1.5}{m_A} \qquad \text{(Given } T_1 = 0.6\,\text{s; } T_2 = 0.5\,\text{s)}$$

$$\frac{36}{25} = \frac{m_A + 1.5}{m_A}$$

$$36m_A = 25m_A + 37.5$$

$$11m_A = 37.5 \Rightarrow m_A = 3.4 \text{ kg}$$

11. (b)

Given:

$$d = 10 \times 18 = 160 \text{ mm}$$

$$D = 10 \times 50 = 500 \text{ mm}$$

$$\phi = 20°$$

$$r_A = \frac{d}{2} + \text{addendum} = 80 + 12 = 92 \text{ mm}$$

$$R_A = \frac{D}{2} + \text{addendum} = 250 + 8 = 258 \text{ mm}$$

$$\text{Path of approach} = \sqrt{R_A^2 - (R\cos\phi)^2} - R\sin\phi$$

$$\text{Path of approach} = \sqrt{258^2 - (250\cos 20°)^2} - (250\sin 20°) = 21.15 \text{ mm}$$

$$\text{Path of recess} = \sqrt{r_A^2 - (r\cos\phi)^2} - r\sin\phi$$

$$= \sqrt{92^2 - (80\cos 20°)^2} - (80\sin 20°) = 25.67 \text{ mm}$$

$$\omega_{gear} = \frac{2\pi\times 800}{60} = 83.77 \text{ rad/s}$$

$$\omega_{pinion} = \frac{T_G}{t_p}\times\omega_{gear} = \frac{50}{16}\times 83.77 = 261.799 \text{ rad/s}$$

Maximum sliding velocity = $(\omega_p + \omega_G) \times 25.67$

Maximum velocity of sliding = $(83.77 + 261.799) \times 25.67 = 887.0756$ mm/s = 8.87 m/s

12. (b)

$$T_A = 72$$
$$T_B = 32$$
$$N_{arm} = 18 \text{ rpm}$$
$$r_A = r_C + 2r_B$$
$$T_A = T_C + 2T_B$$
$$72 = 32 + 2T_B$$
$$T_B = \frac{40}{2} = 20$$

Condition	arm	Gear C (32)	Gear B (20)	Gear A (72)
Arm fixed	0	+1	$-\frac{32}{20}$	$-\frac{32}{20}\times\frac{20}{72}$
Gear c rotate by x revolution	0	x	$-\frac{32}{20}x$	$-\frac{32}{72}x$
add + y revolution to all	y	$x+y$	$y-\frac{32}{20}x$	$y-\frac{32}{72}x$

$$y = 18 \text{ rpm}$$

Gear A is fixed

$$y = \frac{32}{72}x$$

$$y = \frac{32}{72}x$$

$$\frac{18\times 72}{32} = x$$

$$x = 40.5$$

$$\text{Speed of 'B' } N_B = y - \frac{32}{20}x$$

$$= 18 - \frac{32}{20}\times 40.5$$

$$N_B = -46.8 \text{ rpm}$$

13. (c)

Let us assume that the mass M is displaced by an angle θ, then

$$\text{Spring force} = K(b\theta)$$

$$\text{Damping force} = c(a\dot{\theta})$$

Equation of motion can be written as

$$I\ddot{\theta} + Kb(b\theta) + ca(a\dot{\theta}) = 0$$

$$I\ddot{\theta} + ca^2\dot{\theta} + Kb^2\theta = 0$$

$$I = Ma^2$$

$$\ddot{\theta} + \frac{ca^2}{Ma^2}\dot{\theta} + \frac{Kb^2}{Ma^2}\theta = 0$$

On comparing with,

$$\ddot{\theta} + 2\xi\omega_n\dot{\theta} + \omega_n^2\theta = 0$$

$$2\xi\omega_n = \frac{c}{M},\ \omega_n^2 = \frac{K}{M}\frac{b^2}{a^2}$$

For $\xi = 1$, $c = c_c$, $\frac{c_c}{M} = 2\,\omega_n$

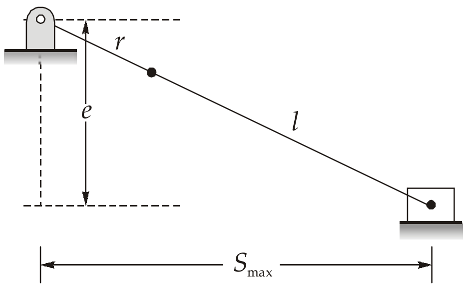
$$\Rightarrow \quad \frac{c_c}{M} = 2\sqrt{\frac{K}{M}\frac{b^2}{a^2}} = \frac{2b}{a}\sqrt{\frac{K}{M}}$$

$$c_c = \frac{2b}{a}\sqrt{KM}$$

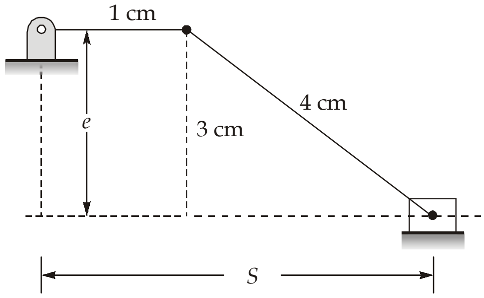
$$c_c = \frac{2\times 0.13}{0.10}\times\sqrt{4900\times 1.5} = 222.90 \text{ N-s/m}$$

14. (b)

At $S = S_{max}$: $\quad r + l = \sqrt{S_{max}^2 + e} = \sqrt{4^2 + 3^2} = 5 \text{ cm}$



Given, $r = 1$ cm, So, $l = 5 - 1 = 4$ cm
at $\theta = 0$:



$$S = \sqrt{4^2 - 3^2} + 1 = \sqrt{7} + 1$$

So, at $\theta = 0$, $S = 3.645$ or 3.65 cm

15. **(a)**

Here, angular velocity of locomotive,

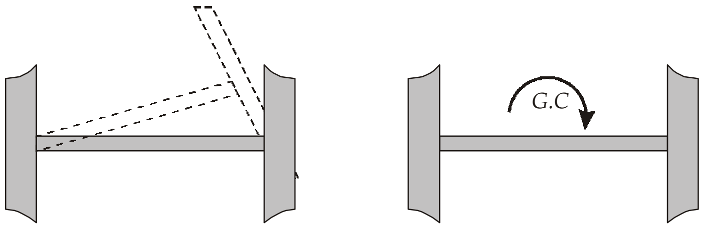
$$\omega = \frac{V}{R} = \frac{95}{0.9 \times 3.6} = 29.3 \text{ rad/s}$$

Wheel precision motion:

$$\text{Amplitude, } A = \frac{1}{2}\text{fall} = \frac{1}{2} \times 6 = 3 \text{ mm}$$

$$V_{max} = A\omega = A \times \left(\frac{2\pi}{t}\right) = 3 \times \frac{2\pi}{0.1} \times 10^{-3} = 0.1885 \text{ m/s}$$

$$(\omega_p)_{max} = \frac{V_{max}}{l} = \frac{0.1885}{1.5} = 0.126 \text{ rad/s}$$



Front View Top View

The Gyroscopic couple set up:

$$C = I\omega\omega_p$$
$$= 180 \times (29.3) \times 0.126$$
$$= 662.76 \text{ Nm}$$

The gyroscopic couple will act in a horizontal plane and this couple will tend to produce swerve i.e. it tends to turn the locomotive aside.

$$R = \frac{C}{l} = \frac{662.84}{1.5} = 441.84 \text{ N}$$

16. **(c)**

For cycloidal cam profile,

$$x = s\left[\frac{\theta}{\theta_0} - \frac{1}{2\pi}\sin\left(\frac{2\pi\theta}{\theta_0}\right)\right]$$

$$v = \frac{\omega s}{\theta_0}\left[1 - \cos\left(\frac{2\pi\theta}{\theta_0}\right)\right]$$

$$a = \frac{2\pi\omega^2 s}{\theta_0^2}\sin\left(\frac{2\pi\theta}{\theta_0}\right)$$

For $a = a_{max}$

$$\frac{2\pi\theta}{\theta_0} = \frac{\pi}{2} \qquad \Rightarrow \theta = \frac{\theta_0}{4}$$

As $$a_{max} = 7102 = \frac{2\pi \times (31.4) \times \left(\frac{2\pi \times 120}{60}\right)^2}{\theta_0^2}$$

$\Rightarrow$ $$\theta_0 = 2.0944 \text{ rad or } 120°$$

17. **(a)**

As per given,

$$E_{max} = E + 120$$

$$E_{min} = E - 52$$

Fluctuation of energy $(\Delta E)_{max} = (E + 120) - (E - 52) = 172 \text{ mm}^2$

$$= 172 \times 600 \times 3 \times \frac{\pi}{180} \text{Nm} = 5403.539 \text{ Nm}$$

$$\Delta E = I\omega^2 c_s$$

$$5403.539 = 0.02 \times 500 \times k^2 \times \left(\frac{2\pi \times 800}{60}\right)^2$$

$$k = 0.277 \text{ m}$$

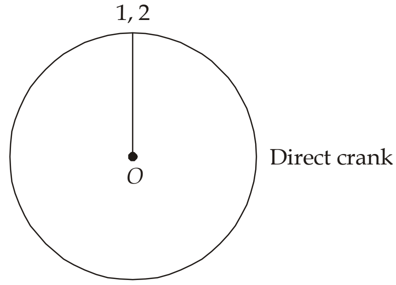
18. **(d)**

Angle between primary direct crank is zero.

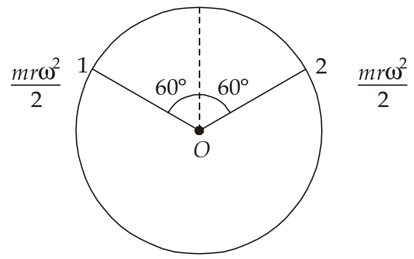
Primary force due to direct crank $= \frac{m}{2}r\omega^2 + \frac{mr}{2}\omega^2 = mr\omega^2$

$$= 1.2 \times \left(\frac{0.1}{2}\right) \times \left(\frac{2\pi \times 2400}{60}\right)^2$$

$$= 3789.9 \approx 3790 \text{ N}$$



Primary reverse crank

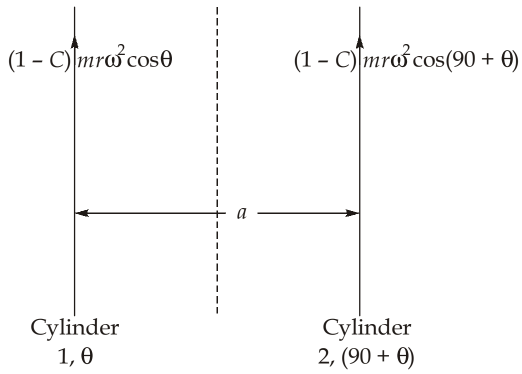


Angle between primary reverse crank = 120°

Primary force due to reverse crank = $2\times\frac{m}{2}r\omega^2\cos 60° = mr\omega^2\cos 60°$

$$= 3790 \cos 60° = 1895 \text{ N}$$

19. (a)



$$\text{Swaying couple} = (1-C)mr\omega^2\left[\cos\theta\frac{a}{2} - \cos(90+\theta)\frac{a}{2}\right]$$

$$= (1-C)mr\omega^2\times\left(\frac{a}{2}\right)(\cos\theta+\sin\theta)$$

$$\omega = \frac{2\pi\times 200}{60} = 20.94 \text{ rad/s}$$

$$\text{Swaying couple} = \left(1-\frac{2}{3}\right)\times 300\times 0.3\times 20.94^2\times\frac{0.65}{2}\times(\cos 60° + \sin 60°)$$

$$= 5840 \text{ Nm} = 5.84 \text{ kNm}$$

20. (c)

$$k = 1 \text{ m}$$
$$m = 2500 \text{ kg}$$
$$T = 1500 \text{ Nm}$$
$$I = mk^2 = 2500 \times 1^2 = 2500 \text{ kgm}^2$$
$$T = I.\alpha$$
$$1500 = 2500\ \alpha$$
$$\alpha = 0.6 \text{ rad/s}^2$$

21. (b)

$$d = 40 \text{ mm}$$
$$t = 15 \text{ mm}$$
$$\text{Number of holes} = 30 \text{ per min}$$
$$\text{Time} = \frac{1}{10} \text{ sec} = 0.1 \text{ sec}$$
$$N_1 = 160 \text{ rpm}$$
$$N_2 = 140 \text{ rpm}$$
$$k = 1 \text{ m}$$
$$\text{Shared area} = \pi d t$$
$$= \pi \times 40 \times 15 = 1884.95 \text{ mm}^2$$
$$\text{Energy required} = 6 \times 1884.95 = 11309.733 \text{ Nm/hole}$$

Energy required to hole per second $= 11309.733 \times \frac{30}{60} = 5654.866$ Nm/s

Energy supplied by the motor,

$$E_2 = 5654.866 \times 0.1 = 565.489 \text{ Nm}$$

$\therefore$ Energy to be supplied by the flywheel during punching a hole $\Delta E = E_1 - E_2$

$$= 11309.733 - 565.486 = 10744.247 \text{ Nm}$$

$$c_s = \frac{(N_1 - N_2)\times 2}{N_1 + N_2} \qquad N = \frac{N_1 + N_2}{2} = 150 \text{ rpm}$$

$$c_s = \frac{(160-140)\times 2}{(160+140)}$$

$$c_s = 0.1333$$

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 150}{60} = 15.707 \text{ rad/s}$$

$$\Delta E = I\omega^2 c_s$$

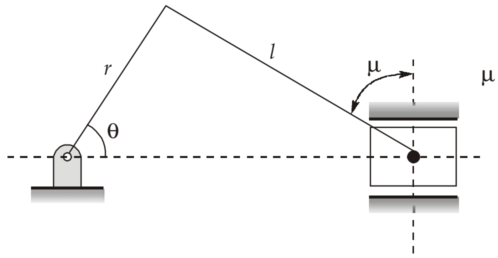
$$10744.247 = m \times 1^2 \times 15.707^2 \times 0.1333$$

$$m = 326.707 \simeq 327 \text{ kg}$$

22. (c)

$$N_1 = 60 \text{ rpm}$$
$$N_2 = 61 \text{ rpm}$$
$$\text{Initial height, } h_1 = \frac{895}{(N_1)^2}$$
$$\text{Height, } h_2 = \frac{895}{(N_2)^2}$$
$$\text{Change in vertical height} = (h_1 - h_2)$$
$$= 895\left[\frac{1}{N_1^2} - \frac{1}{N_2^2}\right]$$
$$= 895\left[\frac{1}{60^2} - \frac{1}{61^2}\right] = 8.08 \text{ mm} \simeq 8 \text{ mm}$$

23. (c)



$$r\sin\theta = l\cos\mu$$

$$\cos\mu = \frac{r}{l}\sin\theta$$

Differentiate with respect to θ

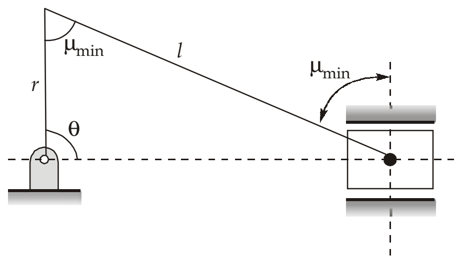
$$-\sin\mu\frac{d\mu}{d\theta} = \frac{r}{l}\cos\theta$$

For μ to be maximum or minimum, $\frac{d\mu}{d\theta} = 0$

$\Rightarrow$ $\cos\theta = 0$

$\theta = 90°$ and $270°$

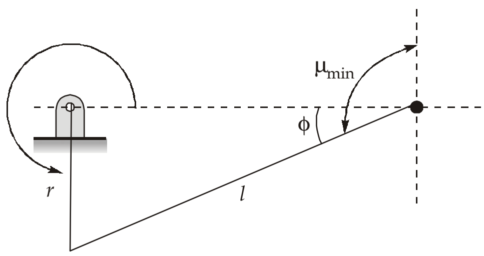
Minimum transmission angle, θ = 90°



$$\cos(\mu_{min}) = \frac{r}{l} = \frac{10}{40} = \frac{1}{4}$$

$$\mu_{min} = 75.52°$$

Maximum transmission angle, θ = 270°



$$\sin\phi = \frac{r}{l} = \frac{10}{40} = \frac{1}{4}$$

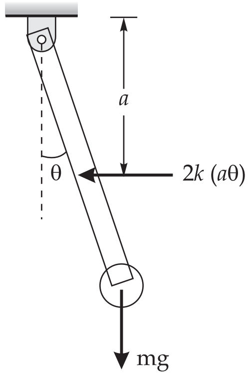
$$\phi = 14.48°$$

So, $\mu_{max} = 90 + \phi = 104.48°$

Difference $= 104.48 - 75.52 = 28.96° \approx 29°$

24. (b)

For a small rotation of θ, the equation of motion can be written as



$$I\ddot{\theta} + 2ka(a\theta) + mg(l\theta) = 0$$

$$I\ddot{\theta} + 2ka^2\theta + mgl\theta = 0$$

$$ml^2\ddot{\theta} + \left(2ka^2 + mgl\right)\theta = 0$$

$$\ddot{\theta} + \left(\frac{2ka^2}{ml^2} + \frac{mgl}{ml^2}\right)\theta = 0$$

$$\ddot{\theta} + \left(\frac{2ka^2}{ml^2} + \frac{g}{l}\right)\theta = 0$$

$$\omega_n = \sqrt{\frac{g}{l} + \frac{2ka^2}{ml^2}} \text{ rad/s}$$

25. (c)

Given, $r = 0.3$ m, $l = 1.5$ m, $N = 180$ rpm, $\theta = 40°$

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 180}{60} = 18.849 \text{ rad/s}$$

$$n = \frac{l}{r} = \frac{1.5}{0.3} = 5$$

Velocity of piston, $v_p = \omega\, r\left(\sin\theta + \frac{\sin 2\theta}{2n}\right)$

$$= 18.849 \times 0.3\left(\sin 40° + \frac{\sin 80°}{2 \times 5}\right) = 4.19 \text{ m/s} \simeq 4.2 \text{ m/s}$$

26. (c)

Given, m = 1 tonne = 1000 kg

Logarithmic decrement of n cycles is given by

$$\delta = \frac{1}{n}\log_e \frac{x_0}{x_n}$$

$n = 4$

$$\delta = \frac{1}{4}\log_e \frac{5}{0.128} = 0.916$$

$$\delta = \frac{2\pi\xi}{\sqrt{1-\xi^2}} \quad \text{or} \quad 0.916 = \frac{2\pi\xi}{\sqrt{1-\xi^2}}$$

$$\xi = 0.144$$

Given, $T_d = 0.64$ seconds

$$\omega_d = \frac{2\pi}{T_d} = \frac{2\pi}{0.64} = 9.817 \text{ rad/s}$$

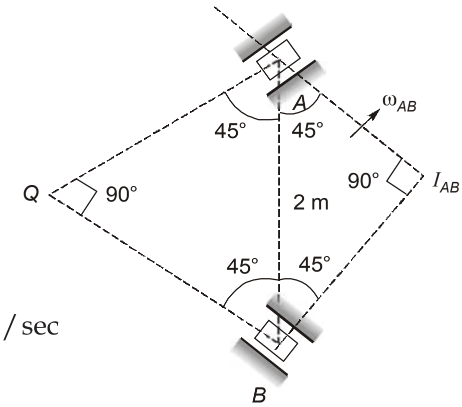
$$\omega_d = \sqrt{1-\xi^2}\,\omega_n$$

$$\omega_n = \frac{9.817}{\sqrt{1-0.144^2}} = 9.92 \text{ rad/s}$$

$$\sqrt{\frac{k}{m}} = 9.92$$

$$k = 9.92^2 \times 1000 = 98406.4 \text{ N/m} = 98.406 \text{ N/mm}$$

27. **(b)**



Length $I_{AB} \cdot A = I_{AB}.B = 2\cos 45°$

$\Rightarrow$ $(I_{AB} \cdot A) = (I_{AB}\,.\,B) = \sqrt{2}$

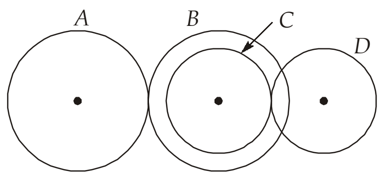
Now $V_A = \omega_{AB}(I_{AB} \cdot A) = 3$ m/sec

$\Rightarrow$ $\omega_{AB} = \dfrac{3}{\sqrt{2}}$ m/sec

$$v_B = (I_{AB} \cdot B)\cdot\omega_{AB} = \sqrt{2} \times \frac{3}{\sqrt{2}} = 3 \text{ m/sec}$$

Also we can directly calculate v_B by symmetry.

28. **(b)**



Given: $T_A = 48$ teeth, $T_B = 72$ teeth, $T_C = 32$ teeth, $T_D = 84$ teeth,

Power, $P_A = 12$ kW at $N = 300$ rpm

$\therefore$ Torque on A, $T_A = \dfrac{P_A \times 60}{2\pi N} = \dfrac{12 \times 60}{2\pi \times 300} = 0.382$ kNm

$$\frac{\omega_A}{\omega_D} = \frac{T_D \times T_B}{T_A \times T_C} = \frac{84 \times 72}{48 \times 32} = 3.9375$$

Power equation $\eta_{GT}\cdot P_{input} + P_{output} = 0$

Efficiency of gear train, $\eta_{GT} = \dfrac{-P_{output}}{P_{input}} = \dfrac{-T_D\omega_D}{T_A\omega_A}$

$$0.9 = \frac{-T_D\omega_D}{0.382 \times \omega_A}$$

$$T_D = -0.9 \times 0.382 \times \frac{\omega_A}{\omega_D} = 0.9 \times 0.382 \times 3.9375$$

$$T_D = -1.35 \text{ kNm}$$

29. (c)

Critical damping coefficient = $2\sqrt{km}$

$$c_c = 2\sqrt{2000\times10}$$

$$c_c = 282.84 \text{ Ns/m}$$

$$\zeta = \frac{c}{c_c} = \frac{200}{282.84} = 0.707$$

$$\text{Logarithmic decrement } \delta = \frac{2\pi\xi}{\sqrt{1-\xi^2}}$$

$$\delta = \frac{2\pi\times0.707}{\sqrt{1-0.707^2}} = 6.28$$

30. (c)

Case I:

Arm	A (108)	C (24)	B (60)
$y = 0$	n	$n \times \frac{108}{24}$	$-n \times \frac{108}{24} \times \frac{24}{60}$
$y = y_0$	$y_0 + n$	$y_0 + \frac{108n}{24}$	$y_0 - \frac{108n}{60}$

$$T_B + 2T_C = T_A$$

$\Rightarrow$ $$T_B = 108 - 2 \times 24 = 60$$

$$N_A = y_0 + n = 0, \qquad n = -y_0$$

$$N_C = y_0 + \frac{9}{2}n, \qquad y_0 + \frac{9}{2}n = 125 \text{ rpm}$$

$\Rightarrow$ $$y_0 - \frac{9}{2}y_0 = 125$$

$$y_0 = -\frac{250}{7}\text{ rpm}$$

$$a = -\frac{250}{7}\text{ rpm}$$

Case II:

$$T_C + 2T_B = T_A$$

$\Rightarrow$ $$T_B = (108 - 24)/2 = 42$$

Arm	A (108)	B (42)	C (24)
$y = 0$	n	$n \times \frac{108}{42}$	$-n \times \frac{108}{42} \times \frac{42}{24}$
$y = y_0$	$y_0 + n$	$y_0 + \frac{18n}{7}$	$y_0 - \frac{9n}{2}$

$$N_A = y_0 + n = 0, \qquad n = -y_0$$

$$N_C = y_0 - \frac{9}{2}n, \qquad y_0 - \frac{9}{2}n = 125 \text{ rpm}$$

$$y_0 = \frac{250}{11}\text{ rpm} \qquad b = \frac{250}{11}\text{ rpm}$$

$$|b-a| = \left|\frac{250}{11} + \frac{250}{7}\right| \times \frac{2\pi}{60} = 6.120 \text{ rad/s}$$

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