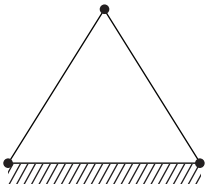
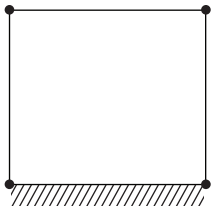
Theory of Machines, Vibrations and Designs Test 1

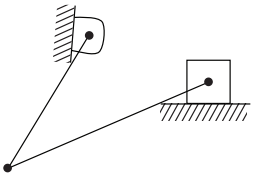
Number of Questions 35 **Time:60 min.**

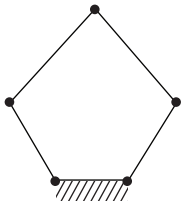
Directions for questions 1 to 35: Select the correct alternative from the given choices.

1. Which of the following are examples of a kinematic chain

(1) 

(2) 

(3) 

(4) 

(A) 1 and 2 (B) 2 and 3
(C) 3 and 4 (D) 1, 2, 3 and 4

2. Match List I and List II and select the correct answer using the codes given below the lists

	List I		List II
P	Undercutting	1	Beam strength
Q	Addendum	2	Interference
R	Lewis equation	3	Large speed reduction
S	Worm and wheel	4	Intersecting axes
		5	Module

Code

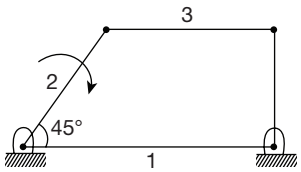
	P	*Q*	*R*	*S*
(A)	1	2	4	3
(B)	2	5	1	3
(C)	1	3	4	5
(D)	2	3	1	5

3. A shaft acting as simple supported beam is having a static deflection of 2.72 mm under a flywheel. The critical speed in rad/sec will be
(A) 60 (B) 24
(C) 12 (D) 6

4. A $M20 \times C4$ bolt of mild steel is having yield stress of 320 MPa and factor of safety 3. The safe static tensile load in kN will be
(A) 67 (B) 16.7
(C) 13.4 (D) 33.5

5. A machine part having a mass of 3 kg vibrates in a viscous medium. An exciting force of 50 N acts on the part and causes a resonant amplitude with a period of 0.25 seconds. The stiffness of the machine part in N/m will be
(A) 1646 (B) 2039
(C) 1895 (D) 1234

6. In the diagram given below, the magnitude of absolute angular velocity of link 2 is 20 rad/sec while that of link 3 is 12 rad/sec. What is the angular velocity of link 3 relative to 2?

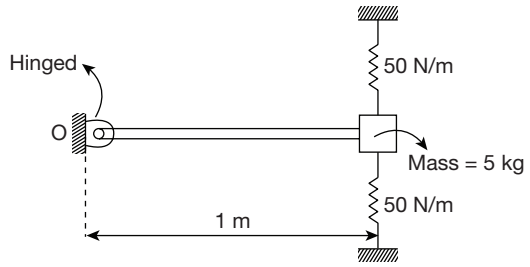


(A) 6 rad/sec (B) 12 rad/sec
(C) 8 rad/sec (D) 18 rad/sec

7. A multi disk clutch consists of steel and bronze plates. The inner and outer diameters of the friction disks are 100 mm and 200 mm. The intensity of pressure on friction lining is limited to 0.5 N/mm^2. For uniform wear theory, the force required to engage the clutch will be
(A) 7854 N (B) 9120 N
(C) 4108 N (D) 5230 N

8. In kinematic chain a quaternary joint is equivalent to
(A) One binary joint (B) Two binary joint
(C) Three binary joint (D) Four binary joint

9. Two springs are attached with a mass of 5 kg as shown in figure



Assuming *EI* of rod = 2.67 N-m^2, calculate natural frequency of the bar in (rad/sec)
(A) $\sqrt{10}$ (B) $\sqrt{20}$
(C) $\sqrt{5}$ (D) $\sqrt{21.6}$

10. Two curved surface having teeth satisfied the law of gearing. Angular velocities of both the surfaces are 4 rad/sec and 6 rad/sec. If the distance between point of contacted surface and pitch point is zero, then sliding velocity of the surface in m/s will be
(A) 10 (B) 6
(C) 4 (D) zero

11. A profile of mating gears is having no interference with variable pressure angle. Flank part is wider in the

mentioned profile as compare to others. Which profile is having all the above characteristics?
(A) Cycloidal (B) Involute
(C) Linear (D) Parabolic

12. In a sliding contact bearing, radius of he journal is 10 cm. If minimum film thickness is 0.001 cm and distance between bearing centre and journal centre is 1×10^{-3} cm then the radius of bearing in cm will be
(A) 10.01 (B) 10.002
(C) 10.02 (D) 10.001

13. A vibratory system consists of a spring of stiffness 5 N/mm and a mass of 10 kg. Mass of spring is 3 kg. The natural frequency of the system in rad/sec is
(A) 22.36 (B) 40.82
(C) 21.32 (D) 20.85

14. A motion is a periodic at what value of the damping factor?
(A) 0.3 (B) 0.5
(C) 0.866 (D) 1.2

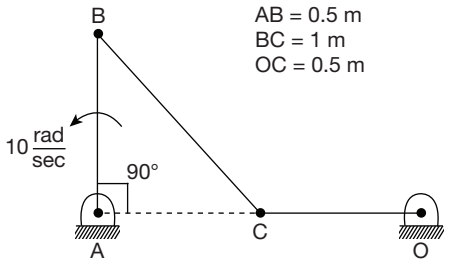
15. For bolts of uniform strength, the shank diameter is made equal to
(A) major diameter of the threads
(B) minor diameter of threads
(C) pitch diameter of threads
(D) nominal diameter of threads

16. A shaft runs at 100 rpm and drives another shaft at 200 rpm through belt drive. The diameter of the driving pulley is 500 mm and belt thickness is 5 mm. If a total slip of 5% is occur then the diameter of the driver pulley in mm will be
(A) 234.8 (B) 247.5
(C) 250 (D) 252.5

17. The distance between two parallel shaft is 20 mm and they are connected by an Oldham's coupling. The driving shaft revolves at 200 rpm. What will be the maximum speed of sliding of the tongue of the intermediate piece along its groove?
(A) 0.56 m/s (B) 0.28 m/s
(C) 0.42 m/s (D) 0.36 m/s

18. A system is supported on a spring with damper has mass of 100 kg. It is given that damping coefficient = 2000 N/m/s; frequency of system = 63.93 rad/sec and amplitude of frequency = 7.2 mm. If transmissibility is 0.08 and spring force is 5000 N then the force applied on vibratory system in N will be
(A) 5084 (B) 63550.5
(C) 5000 (D) 921

19. A mechanism consist of 4 links among those one link is rotating with angular velocity 10 rad/sec as shown in figure. Determine the angular velocity of link BC in rad/sec.

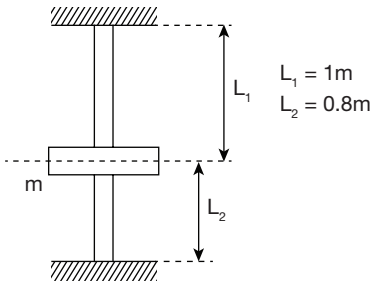


AB = 0.5 m
BC = 1 m
OC = 0.5 m
(A) 5 (B) 10
(C) 12 (D) 20

20. A cone clutch with asbestos friction lining transmits 50 kW power at 900 rpm. The coefficient of friction is 0.2 and the permissible intensity of pressure is 0.5 N/mm^2. The semi cone angle α is 12.5. The outer diameter is fixed as 400 mm from space limitation. Assuming uniform wear theory, the inner diameter (mm) will be
(A) 200 (B) 400
(C) 300 (D) 352

21. Two 20° involute spur gear mesh externally and give a velocity ratio of 4. Module is 4 mm and the addendum is equal to 1.2 module. If the pinion rotates at 200 rpm, then the minimum number of teeth on smaller wheel to avoid interference is
(A) 19 (B) 76
(C) 22 (D) 88

22. A disc is placed in between a shaft and the ends of the shaft are fixed and diameter of the shaft is 50 mm. The disc has a mass of 100 kg and a radius of gyration of 0.5 m. The figure is shown below. If G = 90 GN/m^2 then the frequency of torsional vibration of the disc in Hz will be



(A) 14.12 (B) 8.9
(C) 11.22 (D) 10.12

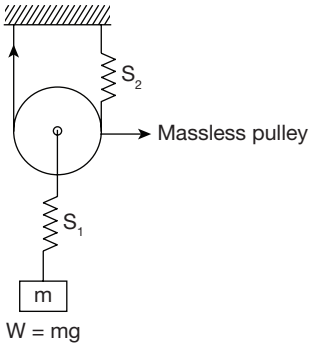
23. A circular shaft 60 mm in diameter, is welded to the support by means of circumferential fillet weld. It is subjected to torsional moment of 3000 N-m. If the permissible shear stress in the weld is limited to 120 N/mm^2, then the size of the weld in mm will be
(A) 4.42 (B) 8.52
(C) 6.25 (D) 5.12

24. What is the value of the radius of gyration of rim type flywheel as compared to disc type flywheel for the same diameter?

(A) $\sqrt{2}$ times (B) $\frac{1}{\sqrt{2}}$ times

(C) 2 times (D) $\frac{1}{2}$ times

25. The frequency (circular) of vibration of the system shown in figure, if $S_1 = S_2 = S$ will be (S = stiffness of the springs)



(A) $\sqrt{\frac{2S}{3m}}$ (B) $\frac{S}{5m}$

(C) $\sqrt{\frac{S}{3m}}$ (D) $\sqrt{\frac{4S}{5m}}$

26. A rotating shaft made of steel 40C8 (S_{ut} = 600 N/mm^2) is subjected to a completely reversed bending stress of 300 N/mm^2. The corrected endsurance limit of the shaft is 100 N/mm^2. Calculate the life (in cycles) of the shaft for a reliability of 90%?

(A) 23736.2 (B) 11117.32

(C) 15958.79 (D) 15230.13

27. Match List I with List II and select the correct code given below the list

	List I		List II
P	Peaucillier inversor	1	Determines acceleration of slider crank mechanism
Q	Reuleaux coupling	2	Approximate straight line mechanism
R	Scott Russel mechanism	3	Far intersecting shaft with load
S	Klin's construction	4	Exact straight line mechanism

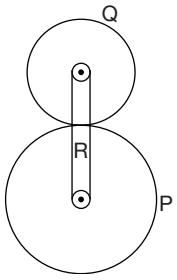
	P	Q	R	S
(A)	2	3	4	1
(B)	2	4	3	1
(C)	1	3	4	2
(D)	1	4	3	2

28. A vibrating system consists of a mass of 30 kg, a spring of stiffness 30 kN/m and a damper. The damping provided is only 15% of the critical value. The natural frequency of damped vibrations in rad/sec is

(A) 24.5 (B) 16.65

(C) 31.2 (D) 29.3

29. In the epicyclic gear train shown in the given figure, P is fixed. P has 120 teeth and Q has 30 teeth. If the arm R makes three revolutions, the number of revolution made by Q will be



(A) 12 (B) 15

(C) 18 (D) 20

30. A rotating shaft carrier flywheel which overhangs on the bearing as a cantilever. If this flywheel weight is increased to double of its original weight, the whirling speed will

(A) be double

(B) increase by $\sqrt{2}$ times

(C) decrease by $\sqrt{2}$ times

(D) be half

31. The following data is given for a 360° hydrodynamic bearing

Radial load = 10 kN
Clearance ratio = 600
Journal speed = 1400 rpm
Viscocity of lubricant = 30 mPas
Diameter of journal = 100 mm
Length of bearing is twice diameter of journal
Calculate Sommerfield number

(A) 0.38 (B) 0.46

(C) 0.42 (D) 0.504

Common data question 32 and 33:

A cylinder of an engine has 500 kg mass is mounted on a steel frame. The static deflection owing to the weight of the frame is 3 mm. The reciprocating masses of the engine amounts to 20 kg and the stroke of the engine is 160 mm. A dashpot with a damping coefficient of 2 N/mm/sec is also used to dampen the vibration

32. The amplitude of vibration if the driving shaft rotates at 500 rpm is

(A) 15.43 mm (B) 11.21 mm

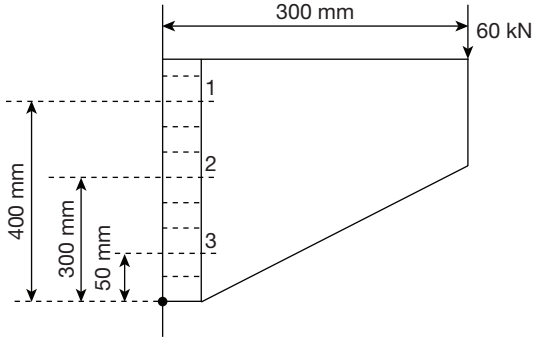
(C) 7.2 mm (D) 9.13 mm

33. The speed of the driving shaft when the resonance occur is

(A) 610 rpm (B) 546 rpm

(C) 596 rpm (D) 445 rpm

Linked answered question 34 and 35:
A bracket is fastened to the steel structure by means of six indentical bolts as shown in figure.



Neglecting shear stress

34. The primary force on the bolt 1 will be
(A) 12630 (B) 13211
(C) 14111 (D) 14650

35. If maximum permissible tensile stress in any bolt is 120 N/mm^2, then area of the bolt in mm^2 will be
(A) 124.2 (B) 99.83
(C) 134.1 (D) 110.1

Answer Keys

1. B	**2.** B	**3.** A	**4.** D	**5.** C	**6.** C	**7.** A	**8.** C	**9.** B	**10.** D
11. A	**12.** B	**13.** C	**14.** D	**15.** B	**16.** A	**17.** C	**18.** B	**19.** D	**20.** B
21. A	**22.** C	**23.** C	**24.** A	**25.** D	**26.** B	**27.** A	**28.** C	**29.** B	**30.** C
31. D	**32.** A	**33.** B	**34.** B	**35.** D					

Hints and Explanations

1. For kinematic chain

$$j = \frac{3}{2}L - 2$$

j = number of binary joints
L = number of links Choice (B)

3. Critical speed $= \sqrt{\frac{g}{\Delta}} = \sqrt{\frac{9.81}{(2.7\times15^3)}}$

= 60 rad/sec. Choice (A)

4. Mean core diameter = 20 mm

$$\sigma = \frac{P}{A}$$

$$\Rightarrow \quad \frac{320}{3} = \frac{P}{\frac{\pi}{4}\times20^2}$$

$\therefore$ P = 33.5 kN. Choice (D)

5. At resonance, $\omega = \omega_n$

$$\therefore \quad \frac{2\pi}{T} = \sqrt{\frac{5}{m}}$$

$$\Rightarrow \quad \left(\frac{2\pi}{0.25}\right)^2 \times 3 = S$$

$\Rightarrow$ S = 1894.964 ~ 1895 N/m. Choice (C)

6. $\omega_{32} = \omega_3 - \omega_2 = 12 - 20$
= – 8 rad/sec
(Negative sign shows the direction is opposite).
Choice (C)

7. $P = \frac{\pi pd}{2}(D-d)$

$$P = \frac{\pi\times0.5\times100}{2}\times(200-100)$$

P = 7854 N. Choice (A)

8. 1 quaternary joint = 3 binary joint. Choice (C)

9. Because of hinged the stiffness of bar will not be considered

$\therefore$ $K_{eq} = K_1 + K_2 = 50 + 50 = 100$ N/m

$\therefore$ $\omega_n = \sqrt{\frac{K_{eq}}{m}} = \sqrt{\frac{100}{5}} = \sqrt{20}$ rad/sec.

Choice (B)

10. $V_{sliding} = (\omega_1 + \omega_2)\times QP$
Given that $QP = 0$
$\therefore$ $V_{sliding} = 0$. Choice (D)

11. Choice (A)

12. Radius of bearing, $R_b = e + R + h_0$
$\therefore$ $R_b = (1\times10^{-3}) + 0.001 + 10$
R_b = 10.002 cm. Choice (B)

13. Natural frequency, $\omega_n = \sqrt{\frac{S}{m+\frac{m}{3}}}$

$\Rightarrow$ ω_n = 21.32 rad/sec. Choice (C)

14. A periodic motion is having in over damped system ($\xi > 1$). The mass does not vibrate at all. Choice (D)

15. There are two ways to make bolt of uniform strength to bear shock load
(a) Diameter of shank = minor diameter
(B) Area of shank reduced to root area.
Choice (B)

16. $\frac{N_2}{N_1} = \left(\frac{D_1 + t}{D_2 + t}\right)\left(\frac{100-5}{100}\right)$

$\Rightarrow \quad \frac{200}{100} = \left[\frac{500+5}{D_2+5}\right]\left[\frac{100-5}{100}\right]$

$\therefore \quad D_2 = 234.8$ mm Choice (A)

17. $\omega = \frac{2\pi \times 200}{60} = 20.944$ rad/sec

Maximum velocity of sliding = $\omega \times d$
$= 20.944 \times 0.02$
$= 0.4188$ m/s ~ 0.42 m/s. Choice (C)

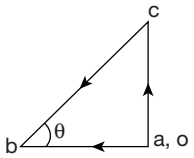
18. $\in = \frac{F_T}{F_o}$

$F_0 = \frac{\sqrt{(SA)^2 + (c\omega A)^2}}{0.08}$

$\Rightarrow \quad F_0 = \frac{\sqrt{(5000)^2 + (2000 \times 63.93 \times 7.2 \times 10^{-3})^2}}{0.08}$

$\therefore \quad F_0 = 63550.5$ N. Choice (B)

19.



$\overrightarrow{ab} = V_{AB} = 10 \times 0.5 = 5$ m/s
From velocity diagram
$\overrightarrow{cb} = \frac{\overrightarrow{ab}}{\cos\theta}$
From diagram
Cos $ABC = \frac{AB}{BC}$
$\Rightarrow \quad \angle ABC = \cos^{-1}\left(\frac{0.5}{1}\right)$
$\therefore \quad \angle ABC = 60°$
$\therefore \quad \angle ACB = 30°$
$\therefore \quad \theta = 60°$
$\overrightarrow{cb} = \frac{5}{\cos 60°}$
$\Rightarrow \quad V_{CB} = \overrightarrow{cb} = 10$ m/s.
$\omega_{CB} = \frac{V_{CB}}{CB}$
$\Rightarrow \quad \omega_{CB} = \frac{10}{0.5} = 20$ rad/sec. Choice (D)

20. $M_t = \frac{60 \times 10^6 \times 50}{2\pi \times 900} = 530516.477$ N/mm

$M_t = \frac{\pi \mu P_a d}{8 \sin\alpha}(D^2 - d^2)$

$530516.477 = \frac{\pi \times 0.2 \times 0.5 \times d}{8 \times \sin(12.5)} \times (400^2 - d^2)$

$\therefore \quad d = 400$ mm. Choice (B)

21. $T = \frac{2 \times a_w}{\sqrt{1 + \frac{1}{G}\left\{\frac{1}{G} + 2\right\}\sin^2\varphi} - 1}$

$T = \frac{2 \times 1.2}{\sqrt{1 + \frac{1}{4}\left\{\frac{1}{4} + 2\right\}\sin^2(20)°} - 1}$

$T = 74$ teeth or 76 teeth
$t = \frac{76}{4} = 19$ teeth. Choice (A)

22. $I = mk^2 = 100 \times 0.5^2$
$I = 25$ kg – m^2
$J = \frac{\pi}{32} \times d^4 = \frac{\pi}{32} \times 0.05^4$
$J = 6.136 \times 10^{-7}$ m^4
$q = q_1 + q_2 = \frac{GJ}{L_1} + \frac{GJ}{L_2}$
$\therefore \quad q = 90 \times 10^9 \times 6.136 \times 10^{-7}\left[\frac{1}{1} + \frac{1}{0.8}\right]$
$q = 124254$ N – m
$f_n = \frac{1}{2\pi}\sqrt{\frac{q}{I}} = \frac{1}{2\pi}\sqrt{\frac{124254}{25}}$
$f_n = 11.22$ Hz. Choice (C)

23. Torsional shear stress $\tau = \frac{M_t}{2\pi t r^2}$

$\therefore \quad t = \frac{3000 \times 10^3}{2\pi \times 30^2 \times 120}$
$t = 4.42$ mm
Size of weld, $h = \frac{t}{0.707} = \frac{4.42}{0.707}$
$\therefore \quad h = 6.253$ mm. Choice (C)

24. For rim flywheel, $K_1 = R$
For disc flywheel, $K_2 = \frac{R}{\sqrt{2}}$
$\therefore \quad K_1 = \sqrt{2}\, K_2$. Choice (A)

25. Force in spring 1 = W = mg
Force in spring 2 = $\frac{W}{2} = \frac{mg}{2}$
Deflection of mass = Deflection of spring 1 + Deflection of spring 2

$$\therefore \quad \Delta = \frac{W}{S_1} + \frac{\frac{W}{2}}{2S_2}$$

$$\Rightarrow \quad \Delta = mg\left[\frac{1}{S_1} + \frac{1}{4S_2}\right]$$

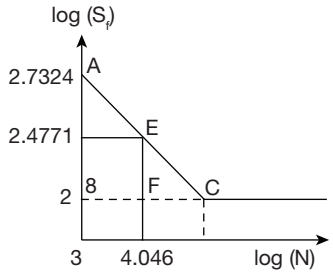
$$\Rightarrow \quad \Delta = mg\left[\frac{4S_2 + S_1}{4S_1S_2}\right]$$

If $S_1 = S_2$, $\Delta = mg\left[\frac{4S_1 + S_1}{4S_1^2}\right]$

$$\Delta = mg\left[\frac{5}{4S_1}\right]$$

$$\therefore \quad \omega_n = \sqrt{\frac{g}{\Delta}} = \sqrt{\frac{4S_1}{5m}}.$$ Choice (D)

26.



$\log(0.9\, S_{ut}) = \log(0.9 \times 600)$

$\Rightarrow \log(0.9 \times 600) = 2.7324$

$\log(S_e) = \log(100)$

$\Rightarrow \log(100) = 2$

$\text{Log}(S_f) = \log(300)$

$\Rightarrow \log(300) = 2.4771$

$$\frac{DE}{AD} = \frac{BC}{AB}$$

$$\Rightarrow \quad DE = \frac{BC \times AD}{AB}$$

$$\Rightarrow \quad DE = \frac{3 \times (2.7324 - 2.4771)}{(2.7324 - 2)} = 1.046$$

$\log(N) = 3 + 1.046 = 4.046$

$\therefore \quad N = 11117.32$ cycles. Choice (B)

27. Choice (A)

28. $\xi = \frac{C}{C_c} = 0.15$

$$\omega_d = \sqrt{1-\xi^2}\ \omega_n = \sqrt{1-0.15^2} \times \sqrt{\frac{S}{m}}$$

$$\Rightarrow \quad \omega_d = \sqrt{1-0.15^2} \times \sqrt{\frac{30 \times 10^3}{30}}$$

$= 31.265$ rad/sec. Choice (C)

29.

Operation	Arm	P	Q
Arm fixed and given 1 revolution to *P*	0	1	$-1 \times \frac{120}{30} = -4$
Multiply by *x*	0	*x*	–4*x*
Adding y revolution	0 + *y*	*x* + *y*	– 4*x* + *y*
	3	0	

$y = 3;\ x = -3$

$\therefore \quad -4x + y = -4(3) + 3$

$= +12 + 3 = 15$ revolution. Choice (B)

30. Deflection, $\Delta = \frac{mgL^3}{3EI}$

$$\omega_n = \omega = \sqrt{\frac{g}{\Delta}} = \sqrt{\frac{3EI}{mL^3}}$$

If $2m$, $\omega_n = \omega = \frac{1}{\sqrt{2}}\sqrt{\frac{3EI}{mL^3}}$. Choice (C)

31. $P = \frac{W}{LD} \Rightarrow P = \frac{10 \times 10^3}{2 \times 0.1^2}$

$\therefore \quad P = 500$ kPa or 0.5 N/mm^2

$$S = \left(\frac{r}{c}\right)^2 \frac{\mu N_s}{P}$$

$$\Rightarrow \quad S = \frac{(600)^2 \times \left(30 \times 10^{-9}\right) \times \left(\frac{70}{3}\right)}{0.5}$$

$S = 0.504$. Choice (D)

32. $\omega = \frac{2\pi \times 500}{60} = 52.36$ rad/sec

$$S \times \Delta = mg \Rightarrow S = \frac{500 \times 9.81}{0.003}$$

$\therefore \quad S = 1.635 \times 10^6$ N/m

$F_0 = mr\omega^2 = 20 \times 0.08 \times (52.36)^2$

$= 4386.5$ N

$$A = \frac{F_0}{\sqrt{\left(S - m\omega^2\right)^2 + (c\omega)^2}}$$

$$= \frac{4386.5}{\sqrt{\left[\left(1.635 \times 10^6\right) - \left(500 \times 52.36^2\right)\right]^2 + (2000 \times 52.36)^2}}$$

$\Rightarrow \quad A = 0.015434$ m or 15.43 mm. Choice (A)

33. $\omega = \omega_n = \sqrt{\frac{S}{m}} = \sqrt{\frac{1.635 \times 10^6}{500}} = 57.2$ rad/sec

$$\frac{2\pi N}{60} = 57.2$$

$\Rightarrow \quad N = 546$ rpm. Choice (B)

34. $P_1 = \dfrac{P(L_1)(L)}{2\left(L_1^2 + L_2^2 + L_3^2\right)}$

$\Rightarrow \quad P_1 = \dfrac{60 \times 10^3 \times 400 \times 300}{2\left[400^2 + 300^2 + 150^2\right]}$

$\Rightarrow \quad P_1 = 13211 \text{ N.}$ Choice (B)

35. $P_1 = A\,(\sigma_1)_{max}$

$13211.01 = A\,(120)$

$\therefore \quad A = 110.1 \text{ mm}^2.$ Choice (D)