PRACTICE QUESTIONS

for SSC-JE : CBT-2

Theory of Machines

Mechanical Engineering

05 Theory of Machines

Q.1 The mass moment of inertia of a flywheel is 2500 kg-m^2 and the starting torque is 1500 Nm. The kinetic energy of the flywheel after 10 seconds of start will be

(a) 18 kNm (b) 25 kNm
(c) 36 kNm (d) 45 kNm

Q.2 The static deflection of a spring under a weight of 15 kg is 4 mm. If gravitational acceleration is 10 m/s^2, then the actual frequency of the spring mass system (in Hz) will be:

(a) 50 (b) 24.6
(c) 16.41 (d) 7.96

Q.3 Match List-I with List-II and select the correct answer using the codes given below:

List-I

A. Node and node
B. Equivalent inertia
C. Logarithmic decrement
D. Resonance

List-II

1. Geared vibration
2. Damped free vibration
3. Forced vibration
4. Multi-rotor vibration

Codes:

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

Q.4 If the helix angle and number of teeth on gear '*A*' are 60°, 45 and for gear '*B*' are 45°, 50 respectively and the normal module for both the gears is 8 mm, then the centre distance between the two shafts will be

(a) 88.76 cm (b) 64.28 cm
(c) 57.22 cm (d) 38.8 cm

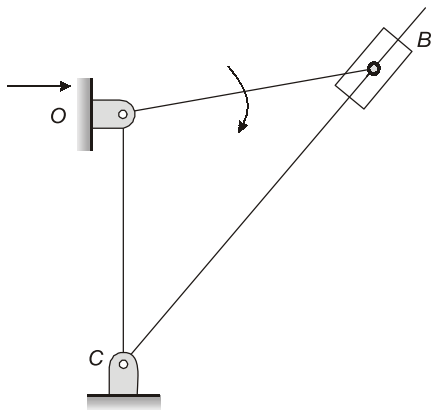
Q.5 What will be the maximum efficiency of worm gear, if the coefficient of friction between teeth is $\frac{1}{\sqrt{3}}$?

(a) 33.33% (b) 66.67%
(c) 57.83% (d) 42.27%

Q.6 A car has wheel base 320 cm and the pivot distance of the front stub axis is 160 cm. When the inner wheel has turned through 45°, then the angle turned by outer front wheel for correct steering will be:

(a) $\cot^{-1}(0.5)$ (b) $\tan^{-1}(0.5)$
(c) $\cot^{-1}(1.5)$ (d) $\tan^{-1}(1.5)$

Q.7 Figure shows a quick return motion mechanism, crank OA rotates clockwise at constant speed. If OA = 4.5 cm and OC = 9 cm, then the ratio of time taken for return motion to forward motion is:



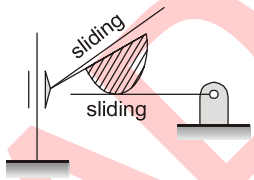
(a) 0.5 (b) 2
(c) 1.5 (d) 1

Q.8 The degree of freedom of a planar linkage, having 7 links and 8 binary joints is:
(a) 0 (b) 1
(c) 2 (d) –1

Q.9 A flywheel is fitted to the crank shaft of an engine having E amount of indicated work per revolution and permissible limits of coefficient of fluctuation of energy and speeds as C_e and C_s respectively. The kinetic energy of flywheel is then given by
(a) $\frac{2C_eE}{C_s}$ (b) $\frac{C_eE}{2C_s}$
(c) $\frac{C_eE}{C_s}$ (d) $\frac{C_sE}{2C_e}$

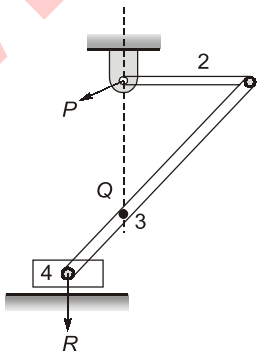
Q.10 The angular velocity of pinion is 20 rad/s and that of gear is 7 rad/s. The path of recess is equal to 16 mm. What is the velocity of sliding at the end of the contact?
(a) 432 mm/s (b) 216 mm/s
(c) 1080 mm/s (d) 2160 mm/s

Q.11 Mobility of mechanism shown below is



(a) 0 (b) 1
(c) 2 (d) 3

Q.12 In the mechanism shown, the location of I_{24} at point



(a) P (b) Q
(c) R (d) 100

Q.13 Consider the following statements:
1. Higher pairs are less resistant than the lower pairs in a plane mechanism.
2. In 4-bar mechanism (with 4 turning pairs) when the link adjacent to shortest link is fixed, crank-rocker mechanism results.

Which of these statement(s) is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q.14 The governor effort is the force exerted by the governor on
(a) upper link (b) lower link
(c) sleeve (d) balls

Q.15 In cycloidal motion of cam follower, the maximum velocity of follower motion V_{max} is
(a) $\pi\frac{h}{2}\left(\frac{\omega}{\phi}\right)$ (b) $\frac{h}{2}\left(\frac{\omega}{\phi}\right)$
(c) $\frac{2h}{\pi}\left(\frac{\omega}{\phi}\right)$ (d) $2h\left(\frac{\omega}{\phi}\right)$

Where:
h = maximum follower displacement
ω = angular velocity of cam
ϕ = angle for the maximum follower displacement for cam rotation

Q.16 Design load factor for a helical gear is smaller than that for a straight tooth spur gear because
(a) Load concentration factor and dynamic load factor are smaller in helical gear.
(b) Both load concentration factor and dynamic load factor are smaller in helical gear.
(c) Load concentration factor is smaller even through dynamic load factor may be higher in helical gear.
(d) Load concentration factor is smaller in helical gear even if the dynamic load factor is the same for both.

Q.17 An aeroplane moving with velocity of 490 km/hr takes a turn along a circular path of radius 700 m. If the angular velocity of rotating part of the plane is 100 rad/s, the moment of inertia of the rotating part is 900 kg-m^2, the gyroscopic couple is

(a) 63 kN-m (b) 44.10 kN-m
(c) 17.5 kN-m (d) 12.25 kN-m

Q.18 Consider the following statements:

1. Balancing of several masses rotating in the same plane can be effected by a single mass.
2. Balancing of several masses in different planes can be done by 2 masses in 2 planes on either sides of the reference plane or on the same side.
3. Reciprocating masses can be completely balanced by rotating masses.
4. Secondary forces are comparable to primary unbalance forces.

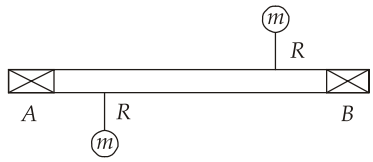
Which of the above statements are incorrect?

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

Q.19 Which of the following statements is correct?

(a) Flywheel reduce speed fluctuations during a cycle for constant load, but flywheel does not control the mean speed of the engine if the load changes.
(b) Flywheel reduces speed fluctuations during a cycle for a constant load, but flywheel does control the mean speed of the engine if the load changes.
(c) Governor controls speed fluctuations during a cycle for a constant load, but governor does not control the mean speed of the engine if the load changes.
(d) Governor controls speed fluctuations during a cycle for a constant load and governor also controls the mean speed of the engine if the load changes.

Q.20 A rotor supported at *A* and *B*, carries two masses as shown below



(a) Dynamically balanced
(b) Statically balanced
(c) Statically and dynamically balanced
(d) Not balanced

Q.21 Consider the following statements:

Transmissibility of vibrations:

1. Is less than 1, when $\frac{\omega}{\omega_n} < \sqrt{2}$
2. Is more than 1, when $\frac{\omega}{\omega_n} > \sqrt{2}$
3. Decreases as damping increases, when $\frac{\omega}{\omega_n} > \sqrt{2}$

Which of the above statement(s) is/are correct?

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

Q.22 The Klein's method of construction for reciprocating engine mechanism

(a) is a simplified version of instantaneous centre method.
(b) utilises a quadrilateral similar to the diagram of mechanism for reciprocating engine.
(c) enables determination of coriolis component.
(d) is based on the acceleration diagram.

Q.23 Match List-I (**Gear train**) with List-II (**Application**) and select the correct answer using the codes given below:

List-I

A. Compound gear train
B. Epicyclic spur gear train with brake bands
C. Worm and worm wheel gear trains
D. Epicyclic bevel gear train

List-II

1. Automobile gear box

2. Automatic transmission of automobile
3. Speed reducers for lifts
4. Automobile differential

Codes:

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

Q.24 What is the minimum number of teeth required on a pinion in order to avoid interference when the pressure angle is 20°, gear ratio is 3 and the standard addendum is one module?
[Take sin20° = 0.342]
(a) 11 (b) 15
(c) 19 (d) 22

Q.25 The damping ratio of a single degree of freedom spring mass damper system with mass 1 kg, stiffness 100 N/m and viscous damping coefficient of 5 Ns/m is
(a) 0.1 (b) 0.17
(c) 0.21 (d) 0.25

Q.26 A flywheel absorbs 32.4 kJ of energy on increasing its speed from 15 rad/s to 25 rad/s. What will be the kinetic energy of the flywheel at 40 rad/s?
(a) 129.6 kJ (b) 86.4 kJ
(c) 69.12 kJ (d) 34.56 kJ

Q.27 Consider the following statements regarding four bar mechanisms:
1. In quick return motion mechanism, Coriolis acceleration exists.
2. Two links in quick return motion mechanism oscillate with one sliding relative to other.
3. In slider crank mechanism, the velocity of piston becomes maximum when crank and connecting rod are in line with each other.

Which of the above statement(s) is/are correct?
(a) 1 only (b) 3 only
(c) 1 and 2 only (d) 2 and 3 only

Q.28 Consider the following statements regarding cam follower mechanism:
1. The follower motion represented on the displacement diagram is achieved by proper cam profile.
2. The cam profile is constructed using the principle of kinematic inversion.

Which of the above statement(s) is/are correct?
(a) 1 only (b) 3 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Q.29 The speed of a driving shaft of a Hooke's joint of angle 30° is 346.4 rpm. The maximum speed of driving shaft is, approximately
(a) 396.44 rpm (b) 400 rpm
(c) 403.11 rpm (d) 404 rpm

Q.30 Consider the following statements regarding power transmission through gears:
1. Larger the contact ratio, more quietly the gears will operate.
2. The contact ratio is the ratio of the length of path of contact to the circular pitch.
3. In cycloidal gears, the contact takes place between a convex flank and concave surface.

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

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Answer Keys

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

Detailed Solutions

1. (d)

As torque, $T = I\alpha$

$\Rightarrow 15000 = 2500 \times \alpha$

$\Rightarrow \alpha = \dfrac{15000}{2500} = 0.6 \text{ rad/s}^2$

After 10 seconds, $\omega_2 = \omega_1 + \alpha t = 0 + 0.6 \times 10$
$= 6$ rad/s

$\Rightarrow \text{KE} = \dfrac{1}{2} I\omega_2^2 = \dfrac{1}{2} \times 2500 \times 6^2 = 45 \text{ kNm}$

2. (d)

Static deflection, $\delta = 4 \text{ mm} = 4 \times 10^{-3}$ m

and $g = 10 \text{ m/s}^2$

$\Rightarrow$ Natural frequency,

$\omega = \sqrt{\dfrac{g}{\delta}} = \sqrt{\dfrac{10}{4 \times 10^{-3}}} = 50 \text{ rad/s}$

or $f = \dfrac{\omega}{2\pi}$ cycle/sec $= 7.96$ Hz

3. (d)

4. (b)

Centre distance between two skew shafts, 'C'

$\Rightarrow C = \dfrac{m_n}{2}\left(\dfrac{T_A}{\cos\psi_A} + \dfrac{T_B}{\cos\psi_B}\right)$

$\Rightarrow C = \dfrac{8}{2}\left(\dfrac{45}{\cos 60°} + \dfrac{50}{\cos 45°}\right)$

$C = 642.84$ mm or 64.28 cm

5. (a)

As $\mu = \tan\phi = \dfrac{1}{\sqrt{3}}$

$\Rightarrow \phi = 30°$

$\Rightarrow \eta_{max} = \dfrac{1 - \sin\theta}{1 + \sin\theta} = \dfrac{1 - \sin 30}{1 + \sin 30} = 33.33\%$

6. (c)

Equation of correct steering,

$$\cot\phi - \cot\theta = \frac{\omega}{L}$$

Where ϕ = Angle turned by outer front wheel

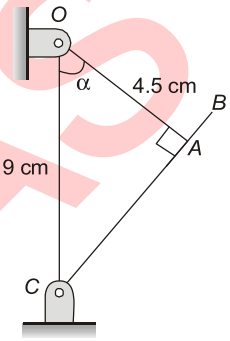
θ = Angle turned by inner front wheel

$\Rightarrow \cot\phi - \cot 45 = \dfrac{160}{320}$

$\Rightarrow \phi = \cot^{-1}(1.5)$

7. (a)

At extreme forward point:



$\Rightarrow \cos\alpha = \dfrac{4.5}{9} = \dfrac{1}{2}$

$\Rightarrow \alpha = 60°$

So, $\dfrac{\text{Time for return stroke}}{\text{Time for forward stroke}}$

$= \dfrac{2\alpha}{360 - 2\alpha} = \dfrac{2 \times 60}{360 - 120} = 0.5$

8. (c)

As DOF, $f = 3(L - 1) - 2j - h$

$\Rightarrow f = 3(7 - 1) - 2 \times 8 - 0 = 2$

9. (b)

$KE = \dfrac{1}{2} I\omega^2 = \dfrac{\Delta E}{2C_s}$ $\quad (\because \Delta E = C_e E)$

$KE = \dfrac{C_e E}{2C_s}$

10. (a)

Velocity of sliding at the end of contact = $(\omega_p + \omega_g) \times$ (path of recess) $= (20 + 7) \times 16$
$= 432$ mm/s

11. (c)

$n = 4$

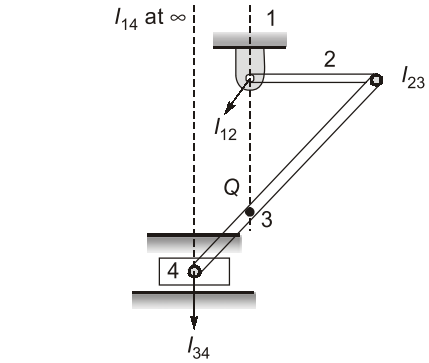
$j = 3$

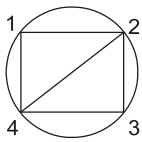
$h = 1$

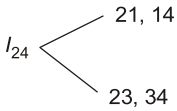
DOF $= F = 3(n-1) - 2j - h$

$= 3 \times (4-1) - 2 \times 3 - 1 = 2$

12. (b)







$\Rightarrow I_{24}$ at point Q.

13. (c)

Lower pairs are more resistant than the higher pairs in a plane mechanism because lower pair have surface contact while higher pair have a point contact.

14. (c)

The effort of a governor is the mean force exerted at the sleeve for a given percentage change of speed.

15. (d)

For cycloidal motion of cam-follower, the velocity is given by,

$$V = \frac{\omega \cdot h}{\phi} \times \left[1 - \cos\left(\frac{2\pi\theta}{\phi}\right)\right]$$

$$V_{max}\Big|_{\theta=\frac{\phi}{2}} = \frac{2 \cdot \omega \cdot h}{\phi}$$

16. (d)

Design load factor for a helical gear is smaller than that for a straight tooth spur gear because load concentration factor is smaller in helical gear even if the dynamic load factor is the same for both.

17. (c)

$$C = I\omega\omega_p = 900 \times 100 \times \frac{490}{700} \times \frac{5}{18} = 17500 \text{ N-m}$$

$= 17.5$ kN-m

18. (d)

Reciprocating masses can't be completely balance by rotating masses. Secondary forces are not comparable to primary unbalance forces.

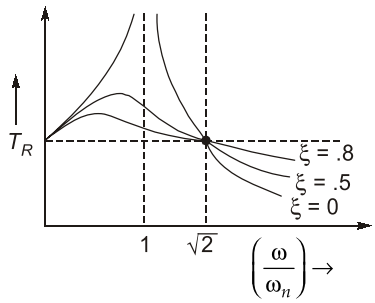
19. (b)

- Flywheel controls the speed variations caused by fluctuations of engine turning moment during a cycle.
- Governor regulates the mean speed of engine within prescribed limit when there are variation of load.

21. (c)

Transmissibility ratio is designated by T_R and is ratio of transmitted force (F_T) to the applied force (F).

$$T_R = \frac{\sqrt{1 + \left(\frac{2\xi\omega}{\omega_n}\right)^2}}{\sqrt{\left(1 - \left(\frac{\omega}{\omega_n}\right)^2\right)^2 + \left(\frac{2\xi\omega}{\omega_n}\right)^2}}$$



T_R decreases as damping increases (ξ decreases) for $\frac{\omega}{\omega_n} > \sqrt{2}$.

24. (b)

Minimum no. of teeth on gear wheel,

$$T = \frac{2a_w}{\sqrt{1+\frac{1}{G}\left(\frac{1}{G}+2\right)\sin^2\theta - 1}}$$

$$T = \frac{2\times 1}{\sqrt{1+\frac{1}{3}\left(\frac{1}{3}+2\right)(0.342)^2 - 1}}$$

$$T = \frac{2}{\sqrt{1.09}-1} = 44.9 \approx 45 \text{ teeth}$$

Teeth on pinion, $t = \frac{T}{G} = \frac{45}{3} = 15$

25. (d)

Damping ratio,

$$\xi = \frac{C}{2\sqrt{km}} = \frac{5}{2\times\sqrt{1\times 100}} = 0.25$$

26. (a)

As, $\Delta E = \frac{1}{2}I\left(\omega_2^2 - \omega_1^2\right)$

$$32400 = \frac{1}{2}\times I\left(25^2 - 15^2\right)$$

$$I = \frac{32400\times 2}{400} = 162 \text{ kg-m}^2$$

At 40 rad/s,

$$E = \frac{1}{2}I\omega^2 = \frac{1}{2}\times 162\times 40^2 = 129.6 \text{ kJ}$$

27. (a)

- One link in quick return mechanism oscillate with one sliding relative to other. One link has rotary motion.
- The velocity of piston in slider crank mechanism becomes maximum when crank is perpendicular to the line stroke of the piston.

29. (b)

As $\left(\frac{\omega_2}{\omega_1}\right)_{max} = \frac{1}{\cos\alpha}$

$$\omega_2 = \frac{\omega_1}{\cos\alpha}$$

$$\Rightarrow N_{2,max} = \frac{N_1}{\cos\alpha} = \frac{346.4}{\cos 30°}$$

$$N_{2,max} = \frac{346.4}{\frac{\sqrt{3}}{2}} = \frac{2\times 346.4}{1.732}$$

$$N_{2,max} = 400 \text{ rpm}$$

30. (c)

$$\text{Contact ratio} = \frac{\text{Length of arc of contact}}{\text{Circular pitch}}$$

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