Multiple-Choice Questions

1. The lead screw of a lathe with nut is a
   (a) sliding pair
   (b) turning pair
   (c) rolling pair
   (d) screw pair
2. In a kinematic pair, when the elements have surface contact while in motion, it is a
   (a) higher pair
   (b) closed pair
   (c) lower pair
   (d) spherical pair
3. In kinematic chain, a ternary joint is equivalent to
   (a) one binary joint
   (b) two binary joints
   (c) three binary joints
   (d) six binary joints
4. In kinematic chain, a quaternary joint is equivalent to
   (a) one binary joint
   (b) two binary joints
   (c) three binary joints
   (d) six binary joints
5. In a four-link mechanism, the sum of the shortest and the longest links is less than the sum of the other two links. Will it act as a drag-crank mechanism?
   (a) No.
   (b) Yes, if the shortest link is fixed.
   (c) Yes, if the link opposite to the shortest link is fixed.
   (d) Yes, if any link adjacent to shortest link is fixed.
6. In a four-link mechanism, the sum of the shortest and the longest links is less than the sum of the other two links. Will it act as a rocker-rocker mechanism?
   (a) No.
   (b) Yes, if the shortest link is fixed.
   (c) Yes, if the link opposite to the shortest link is fixed.
   (d) Yes, if any link adjacent to shortest link is fixed.
7. In a four-link mechanism, the sum of the shortest and the longest links is less than the sum of the other two links. Will it act as a crank-rocker mechanism?
   (a) No.
   (b) Yes, if the shortest link is fixed.
   (c) Yes, if the link opposite to the shortest link is fixed.
   (d) Yes, if any link adjacent to shortest link is fixed.

8. Transmission angle is maximum when crank angle with the fixed link is
(a) 0° (b) 90°
(c) 180° (d) 270°
9. Transmission angle is minimum when crank angle with the fixed link is
(a) 0° (b) 90°
(c) 180° (d) 270°
10. Which of the following is an unclosed or open pair?
(a) Journal bearing (b) Lead screw and nut
(c) Cam and follower (d) Ball and socket joint
11. In a crank- and slotted-lever mechanism, if the lengths of the crank and the fixed links are 100 mm and 200 mm respectively, what will be the ratio of cutting time to the return time?
(a) 0.5 (b) 1
(c) 2 (d) 4
12. *ABCD* is a four-link mechanism. $AB = 100$ mm, $BC = 150$ mm, $CD = 200$ mm and $AD = 175$ mm. Can it act as a double-crank mechanism?
(a) No. (b) Yes, if *AB* is fixed
(c) Yes, if *BC* is fixed (d) Yes, if *AD* is fixed
13. *ABCD* is a four-link mechanism. *AD* is the fixed link. $AB = 30$ mm, $BC = 50$ mm, $CD = 60$ mm and $AD = 70$ mm. It is a ________ mechanism.
(a) crank-rocker (b) double-crank
(c) double-rocker (d) None of these
14. Which mechanism generates intermittent rotary motion from continuous rotary motion?
(a) Elliptical trammel (b) Geneva mechanism
(c) Scotch-yoke mechanism (d) Whitworth mechanism
15. Two parallel shafts with small distance between their shafts can be connected by
(a) universal coupling (b) flexible coupling
(c) rigid coupling (d) Oldham's coupling
16. Transmission angle is the angle between the
(a) input link and the coupler (b) output link and the coupler
(c) input link and the fixed link (d) output link and the fixed link
17. In a slider-crank mechanism, considering the crank and the coupler as the two sides and the line of stroke as base of a triangle, the maximum area is obtained when the crank angle is 75°. The l/r ratio will be
(a) 3 (b) 3.73
(c) 4.73 (d) 4
18. The number of inversions for a slider-crank chain is
(a) 3 (b) 4
(c) 5 (d) 6
19. Which of the following is an inversion of double-slider-crank chain?
(a) Whitworth quick-return mechanism (b) Reciprocating compressor
(c) Scotch yoke (d) Rotary engine
20. Oldham's coupling is used to connect two shafts which are
(a) intersecting (b) parallel
(c) perpendicular (d) co-axial
21. Inversion of a mechanism means
(a) turning it upside down (b) fixing different links in a kinematic chain
(c) changing a higher pair to lower pair (d) changing the input and the output links
22. Which of the following is an inversion of single-slider-crank chain?
(a) Elliptical trammel (b) Hand pump
(c) Scotch yoke (d) Oldham's coupling

23. Which of the following mechanism is obtained if the slider of a single-slider-crank chain is fixed?
(a) Quick-return mechanism
(b) Oscillating cylinder
(c) Rotary engine
(d) Hand pump

24. Oldham's coupling is an inversion of a kinematic chain also used in
(a) universal joint
(b) elliptical trammel
(c) hand pump
(d) rotary engine

25. A quick-return mechanism is an inversion of
(a) single-slider-crank chain
(b) double-slider-crank chain
(c) four-bar chain
(d) crossed-slider-crank chain

26. For a four-bar linkage in *toggle* position, the value of mechanical advantage is
(a) 0.0
(b) 0.5
(c) 1.0
(d) ∞

27. The number of degrees of freedom of the linkage shown in Fig. 1.68 is
(a) –3
(b) 0
(c) 1
(d) 2

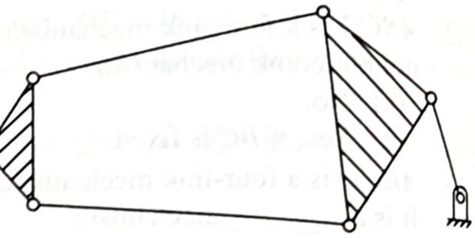

Fig. 1.68

28. A four-bar mechanism with all revolute pairs has link lengths $l_f = 20$ mm, $l_{in} = 40$ mm, $l_{co} = 50$ mm and $l_{out} = 60$ mm. The suffixes '*f*', 'in', 'co' and 'out' denote the fixed link, the input link, the coupler and output links respectively. Which one of the following statements is true about the input and output links?
(a) Both links can execute full-circular motion
(b) Both links cannot execute full-circular motion
(c) Only the output link cannot execute full-circular motion
(d) Only the input link cannot execute full-circular motion

29. A planar-closed kinematic chain is formed with rigid links $PQ = 2.0$ m, $QR = 3.0$ m, $RS = 2.5$ m and $SP = 2.7$ m with all revolute joints (Fig. 1.69). The link to be fixed to obtain a double-rocker (rocker-rocker) mechanism is
(a) PQ
(b) QR
(c) RS
(d) SP

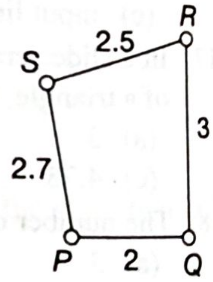

Fig. 1.69

30. Which of the following statements is incorrect?
(a) Grashof's rule states that for a planar crank-rocker four-bar mechanism, the sum of the shortest and the longest link lengths cannot be less than the sum of the remaining two link lengths.
(b) Inversions of a mechanism are created by fixing different links one at a time.
(c) Geneva mechanism is an intermittent motion device.
(d) Grübler's criterion assumes mobility of a planar mechanism to be one.

31. A double-parallelogram mechanism is shown in Fig. 1.70. Note that PQ is a single link. The mobility of the mechanism is
(a) –1
(b) 0
(c) 1
(d) 2

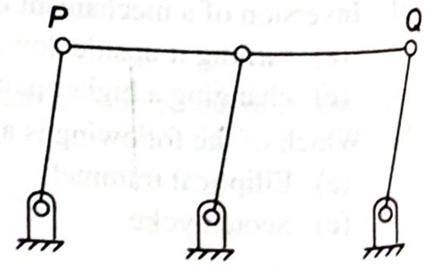

Fig. 1.70

32. *Match the following*

Column I	Column II
(P) Higher kinematic pair	(1) Grübler's equation
(Q) Lower kinematic pair	(2) Line contact
(R) Quick return mechanism	(3) Euler's equation
(S) Mobility of a linkage	(4) Planer
	(5) Shaper
	(6) Surface contact

(a) (P)-(2), (Q)-(6), (R)-(4), (S)-(3)
(b) (P)-(6), (Q)-(2), (R)-(4), (S)-(1)
(c) (P)-(6), (Q)-(2), (R)-(4), (S)-(3)
(d) (P)-(2), (Q)-(6), (R)-(5), (S)-(1)

33. *Match the following*

Type of Mechanism	Motion achieved
(P) Scott – Russel mechanism	(1) Intermittent motion
(Q) Geneva mechanism	(2) Quick return motion
(R) Offset slider-crank mechanism	(3) Simple harmonic motion
(S) Scotch Yoke mechanism	(4) Straight line motion

(a) (P)-(2), (Q)-(3), (R)-(1), (S)-(4)
(b) (P)-(3), (Q)-(2), (R)-(4), (S)-(1)
(c) (P)-(4), (Q)-(1), (R)-(2), (S)-(3)
(d) (P)-(4), (Q)-(3), (R)-(1), (S)-(2)

34. Match the following with respect to spatial mechanisms:

Type of Joint	Degree of constraint
(P) Revolute	(1) Three
(Q) Cylindrical	(2) Five
(R) Spherical	(3) Four
	(4) Two
	(5) Zero

(a) (P)-(4), (Q)-(3), (R)-(3)
(b) (P)-(5), (Q)-(4), (R)-(3)
(c) (P)-(2), (Q)-(3), (R)-(1)
(d) (P)-(4), (Q)-(5), (R)-(3)

35. The lengths of the links of a four-bar linkage with revolute pairs only are p, q, r and s units. Given that $p < q < r < s$. Which of these links should be the fixed one, for obtaining a *double-crank* mechanism?
(a) Link of length p
(b) Link of length q
(c) Link of length r
(d) Link of length s

36. The minimum number of links in a single degree-of-freedom planar mechanism with both higher and lower kinematic pairs is
(a) 2
(b) 3
(c) 4
(d) 5

37. The mechanism used in a shaping machine is
(a) A closed 4-bar chain having 4 revolute pairs
(b) A closed 6-bar chain having 6 revolute pairs
(c) A closed 4-bar chain having 2 revolute and 2 sliding pairs
(d) An inversion of the single-slider-crank chain

38. In a four-bar linkage, S denotes the shortest link length, L is the longest link length, P and Q are the lengths of other two links. At least one of the three moving links will rotate by 360° if

(a) $S+L \le P+Q$ (b) $S+L > P+Q$
(c) $S+P \le L+Q$ (d) $S+P > L+Q$

39. For a mechanism shown in Fig. 1.71, the mechanical advantage for the given configuration is

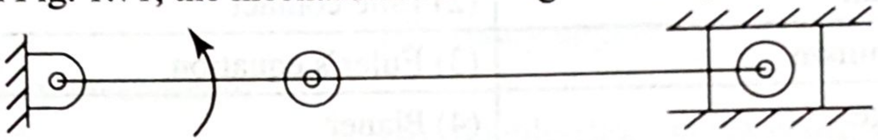

Fig. 1.71

(a) 0 (b) 0.5
(c) 1.0 (d) ∞

40. The number of degrees of freedom of a planar linkage with 8 links and 9 simple revolute joints is

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

41. Mobility of a statically indeterminate structure is

(a) −1 (b) 0
(c) 1 (d) ≥ 2

Answers to Multiple-Choice Questions

1. (d)	2. (c)	3. (b)	4. (c)	5. (b)	6. (c)	7. (d)
8. (c)	9. (a)	10. (c)	11. (c)	12. (b)	13. (a)	14. (b)
15. (d)	16. (b)	17. (b)	18. (b)	19. (c)	20. (b)	21. (b)
22. (b)	23. (d)	24. (b)	25. (a)	26. (d)	27. (c)	28. (a)
29. (c)	30. (a)	31. (c)	32. (d)	33. (c)	34. (c)	35. (a)
36. (c)	37. (d)	38. (a)	39. (d)	40. (c)	41. (a)	

Multiple-Choice Questions

1. The linear velocity of a point B on a link rotating at an angular velocity ω relative to another point A on the same link is
   (a) $\omega^2 \cdot AB$
   (b) $\omega \cdot AB$
   (c) $\omega \cdot (AB)^2$
   (d) ω / AB
2. The linear velocity of a point on a link relative to another point on the same link is ______ to the line joining the points.
   (a) perpendicular
   (b) parallel
   (c) at 45°
   (d) none of these
3. $ABCD$ is a four-bar mechanism. AD is the fixed horizontal link. $AB = 300$ mm and $CD = 450$ mm. Both AB and DC are perpendicular to the fixed link at the instant. If the velocity of B is 2 m/s, then the velocity of C is
   (a) 2/3 m/s
   (b) 2 m/s
   (c) 3/2 m/s
   (d) 2.25 m/s
4. Two points located along the radius of a wheel have velocities of 8 m/s and 14 m/s respectively. The distance between the points is 300 mm. Radial distance of outer point from the centre is
   (a) 500 mm
   (b) 600 mm
   (c) 700 mm
   (d) 800 mm
5. A thin circular disc rolls on a plane surface along a straight path with a uniform speed. Which of the following statements are correct for the motion?
   (a) All points on the disc have same velocity.
   (b) The centre of the disc has centripetal acceleration.
   (c) The contact point of the disc has zero acceleration.
   (d) The centre of the disc has zero acceleration.
6. $ABCD$ is a four-bar mechanism. AD is the fixed link. At the instant AB and DC are vertical whereas BC is horizontal. AB is shorter than DC by 300 mm. The angular velocities of AB and DC are 5 rad/s and 2 rad/s respectively. The length of AB is
   (a) 100 mm
   (b) 200 mm
   (c) 300 mm
   (d) 500 mm
7. In a slider-crank mechanism, the velocity of the piston is maximum when
   (a) crank and connecting rod are perpendicular to each other
   (b) crank and connecting rod are in the same line
   (c) crank is perpendicular to the line of stroke
   (d) crank is at 120° with the line of stroke
8. Two links OA and OB are connected by a pin joint at O. The angular velocities of OA and OB are ω_a and ω_b in the clockwise and counter-clockwise respectively. If the radius of pin at O is r, the rubbing velocity is
   (a) $(\omega_a + \omega_b)r$
   (b) $(\omega_a - \omega_b)r$
   (c) $(\omega_a + \omega_b)2r$
   (d) $(\omega_a - \omega_b)2r$
9. The total number of instantaneous centres of a mechanism having 6 links is
   (a) 6
   (b) 9
   (c) 12
   (d) 15

10. The total number of instantaneous centres of a mechanism having n links is

(a) $\dfrac{n(n-1)}{2}$ (b) $\dfrac{n-1}{2}$

(c) $\dfrac{n(n+1)}{2}$ (d) $\dfrac{n+1}{2}$

11. According to Kennedy's theorem, the instantaneous centres of three bodies having relative motion lie on a

(a) curved path (b) straight line

(c) point (d) none of these

12. The instantaneous centre of a slider moving in a linear guide lies

(a) at pin point (b) at the front of the guide

(c) at infinity (d) anywhere on the surface

13. The instantaneous centre of a slider moving in a curved surface lies

(a) at infinity (b) at their point of contact

(c) at centre of curvature (d) at pin point

14. The instantaneous centre of rotation of a circular disc rolling on a straight path is

(a) at the centre of the disc (b) at their point of contact

(c) at the centre of gravity of the disc (d) at infinity

15. The locus of instantaneous centre of a moving body relative to a fixed body is known as

(a) space centrode (b) body centrode

(c) moving centrode (d) none of above

16. The space centrode of a circular disc rolling on a straight path is

(a) a circle (b) a parabola

(c) a straight line (d) none of above

17. *ABCD* is a four-link mechanism. *AD* is the fixed link. Link *BC* is in the form of a circular disc with centre *O* on which *B* and *C* are pivots. *O* will be instantaneous centre of the disc if it lies on the

(a) intersection of the perpendicular bisectors of *AD* and *BC*

(b) intersection of the perpendicular bisectors of *AB* and *DC*

(c) intersection of extensions of *AB* and *DC*

(d) perpendicular bisector of *BC*

18. Instantaneous centre of a body rolling with sliding on a stationary curved surface lies

(a) at the point of contact

(b) on the common normal at the point of contact

(c) on the common tangent at the point of contact

(d) at the centre of curvature of the stationary surface

19. There are two points *P* and *Q* on a planar rigid body. The relative velocity between the two points

(a) Should always be along *PQ*

(b) Can be oriented along any direction

(c) Should always be perpendicular to *PQ*

(d) Should be along *QP* when the body undergoes pure translation

20. A rigid link *PQ* is undergoing plane motion as shown in Fig. 2.70 (V_P and V_Q are non-zero). V_{QP} is the relative velocity of point *Q* with respect to point *P*. Which one of the following is TRUE?

(a) V_{QP} has components along and perpendicular to *PQ*

(b) V_{QP} has only one component directed from *P* to *Q*

(c) V_{QP} has only one component directed from *Q* to *P*

(d) V_{QP} has only one component perpendicular to *PQ*

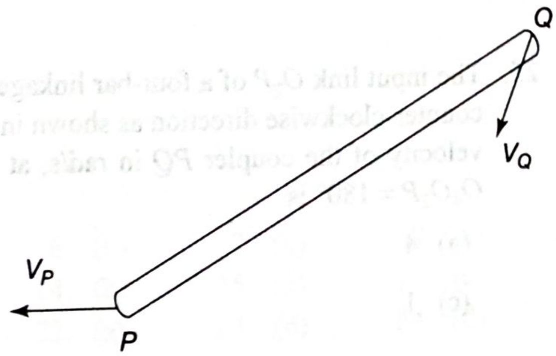

Fig. 2.70

21. Figure 2.71 shows a wheel rotating about O_2. Two points A and B located along the radius of wheel have speeds of 80 m/s and 140 m/s respectively. The distance between the points A and B is 300 mm. The diameter of the wheel is _______ mm.

(a) 700 (b) 350
(c) 2800 (d) 1400

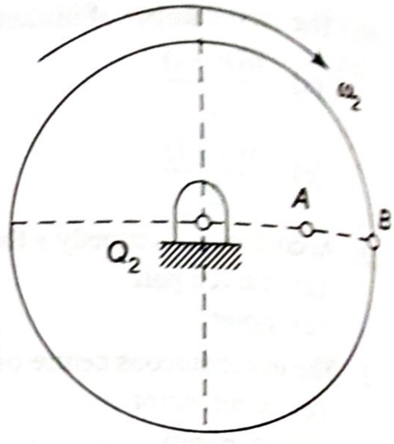

Fig. 2.71

22. A slider-crank mechanism with crank radius 60 mm and connecting rod length 240 mm is shown in Fig. 2.72. The crank is rotating with a uniform angular speed of 10 rad/s, counter clockwise. For the given configuration, the speed of the slider is _______ m/s.

(a) 0.62 (b) 1.24
(c) 0.31 (d) 2.48

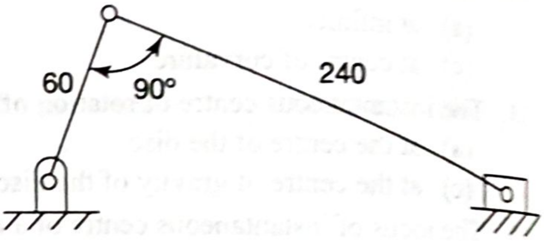

Fig. 2.72

23. For the four-bar linkage shown in Fig. 2.73, the angular velocity of link AB is 1 rad/s. The length of link CD is 1.5 times the length of link AB. In the configuration shown, the angular velocity of link CD in rad/s is

(a) 3 (b) $\frac{3}{2}$

(c) 1 (d) $\frac{2}{3}$

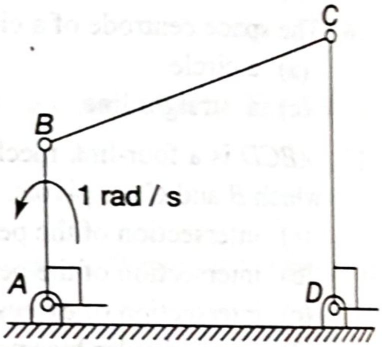

Fig. 2.73

24. A rigid link PQ is 2 m long and oriented at 20° to the horizontal as shown in Fig. 2.74. The magnitude and direction of velocity V_Q, and the direction of velocity V_P are given. The magnitude of V_P in m/s at this instant is

(a) 2.14 (b) 1.89
(c) 1.21 (d) 0.96

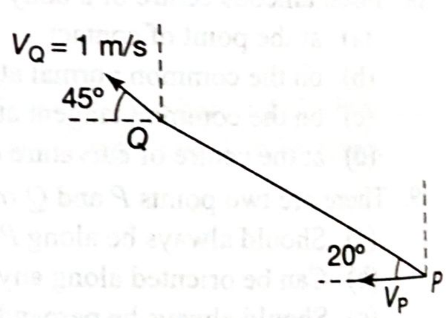

Fig. 2.74

25. The input link O_2P of a four-bar linkage is rotated at 2 rad/s in counter-clockwise direction as shown in Fig. 2.75. The angular velocity of the coupler PQ in rad/s, at an instant when angle $O_4O_2P = 180°$ is

(a) 4 (b) $2\sqrt{2}$

(c) 1 (d) $1\sqrt{2}$

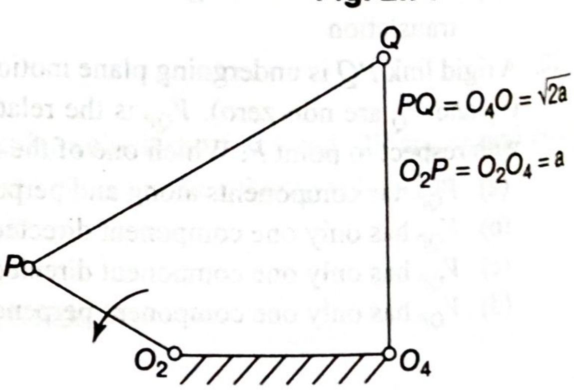

Fig. 2.75

26. Figure 2.76 shows a planar mechanism with single degree of freedom. The instant centre 24 for the given configuration is located at a position
    (a) L
    (b) M
    (c) N
    (d) ∞

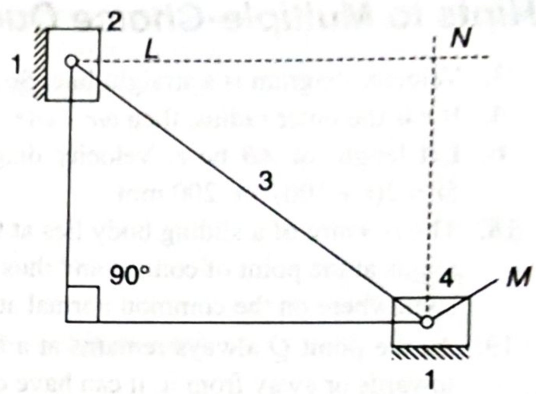

Fig. 2.76

27. The circular disc shown in its plane view in Fig. 2.77 rotates in a plane parallel to the horizontal plane about the point O at a uniform angular velocity, ω. Two other points A and B are located on the line OZ at distances r_A and r_B from O respectively. The velocity of point B with respect to point A is a vector of magnitude
    (a) 0
    (b) $\omega(r_B - r_A)$ and direction opposite to the direction of motion of point B
    (c) $\omega(r_B - r_A)$ and direction same as the direction of motion of point B
    (d) $\omega(r_B - r_A)$ and direction being from O to Z

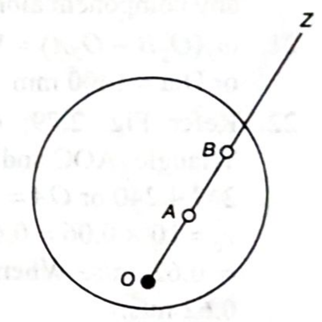

Fig. 2.77

28. Figure 2.78 shows a quick-return mechanism. The crank OA rotates clockwise uniformly. $OA = 2$ cm; $OO' = 4$ cm. The ratio of time for forward motion to that for return motion is
    (a) 0.5
    (b) 2.0
    (c) $\sqrt{2}$
    (d) 1

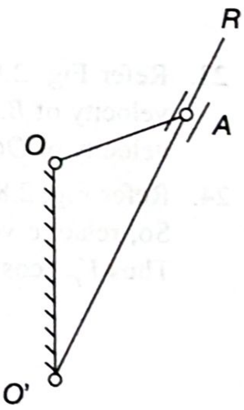

Fig. 2.78

29. A circular object of radius 'r' rolls without slipping on a horizontal level floor with the centre having velocity V. The velocity at the point of contact between the object and the floor is
    (a) Zero
    (b) V in the direction of motion
    (c) V opposite to the direction of motion
    (d) V vertically upward from the floor

Answers to Multiple-Choice Questions

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

Multiple-Choice Questions

1. The component of the acceleration directed towards the centre of rotation of a revolving body is known as ______ component.
   - (a) tangential
   - (b) centripetal
   - (c) coriolis
   - (d) central
2. At an instant, link AB of length r has an angular velocity ω and angular acceleration a. What is the total acceleration of AB?
   - (a) $[(\omega^2 . r)^2 + (a . r)^2]^{1/2}$
   - (b) $[(\omega . r)^2 + (a . r)^2]^{1/2}$
   - (c) $[(\omega^2 . r)^2 + (a^2 . r)^2]^{1/2}$
   - (d) $[(\omega . r)^2 + (a^2 . r)^2]^{1/2}$
3. At an instant, if the angular velocity of a link is clockwise, then the angular deceleration will be
   - (a) clockwise
   - (b) counter-clockwise
   - (c) in any direction (clockwise or counter-clockwise)
   - (d) None of these

4. Angular acceleration of a link AB is given by
   (a) $\dfrac{\text{Centripetal acceleration}}{\text{Length } AB}$ (b) $\dfrac{\text{Tangential acceleration}}{\text{Length } AB}$
   (c) $\dfrac{\text{Total acceleration}}{\text{Length } AB}$ (d) None of these
5. A slider moves with uniform velocity v on a revolving link of length r with angular velocity ω. The Coriolis acceleration component of a point on the slider relative to a coincident point on the link is equal to
   (a) $2\, r\, \omega$ parallel to link (b) $2\, \omega\, v$ perpendicular to link
   (c) $2\, r\, \omega$ perpendicular to link (d) $2\, \omega\, v$ parallel to link
6. Coriolis acceleration component is taken into account for a _____ mechanism.
   (a) double-slider crank (b) four-link mechanism
   (c) Scotch yoke (d) crank and slotted-lever quick-return mechanism
7. Coriolis acceleration component
   (a) lags the sliding velocity by 90° (b) leads the sliding velocity by 90°
   (c) lags the sliding velocity by 180° (d) leads the sliding velocity by 180°
8. The sense of Coriolis component of acceleration is given by rotating the relative velocity vector by _____ rotation of the link containing the path.
   (a) 45° in the direction of (b) 45° in the direction opposite to
   (c) 90° in the direction of (d) 90° in the direction opposite to
9. The Coriolis component of acceleration depends on
   (a) velocity and acceleration of the slider
   (b) angular velocity and angular acceleration of the link
   (c) velocity of the slider and angular velocity of the link
   (d) acceleration of slider and angular velocity of the link
10. Coriolis acceleration component of a slider moving at 150 mm/s on a link rotating at 60 rpm will be
   (a) $600\, \pi$ mm/s^2 (b) $300\, \pi$ mm/s^2
   (c) $600\, \pi^2$ mm/s^2 (d) $300\, \pi^2$ mm/s^2
11. In Fig 3.40, link rotates with constant angular velocity ω_2. A slider link 3 moves outwards with a constant relative velocity $V_{Q/P}$, where Q is a point on slider 3 and P is a point on link 2. The magnitude and direction of Coriolis component of acceleration is given by
   (a) $2\omega_2\, V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction ω_2
   (b) $\omega_2\, V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction ω_2
   (c) $2\omega_2\, V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° opposite to the direction of ω_2
   (d) $\omega_2\, V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° opposite to the direction ω_2

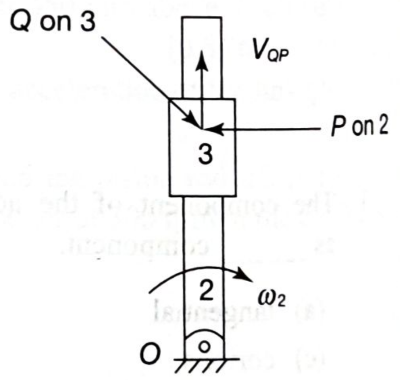

Fig. 3.40

12. A rigid link PQ of length 2 m rotates about the pinned end Q with a constant angular acceleration of 12 rad/s^2. When the angular velocity of the link is 4 rad/s, the magnitude of the resultant acceleration of the end P is _____ m/s^2.
   (a) 30 (b) 40
   (c) 20 (d) 50
13. A link OB is rotating with a constant angular velocity of 2 rad/s in counter-clockwise direction and a block is sliding radially outwards on it with a uniform velocity of 0.75 m/s with respect to the rod as shown in the Fig. 3.41. If OA = 1 m, the magnitude of the absolute acceleration of the block at location A is _____ m/s^2.
   (a) 3 (b) 4
   (c) 5 (d) 6

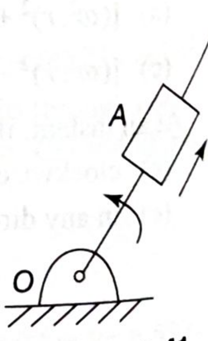

Fig. 3.41

14. A solid disc of radius r rolls without slipping on the horizontal floor with angular velocity ω and angular acceleration α. The magnitude of acceleration of the point of contact on the disc is
    (a) zero
    (b) $r\alpha$
    (c) $\sqrt{(r\alpha)^2 + (r\omega^2)^2}$
    (d) $r\omega^2$
15. The Coriolis component of acceleration is present in
    (a) Four-bar mechanisms with four turning pairs
    (b) Shaper mechanism
    (c) Slider-crank mechanism
    (d) Scotch-yoke mechanism
16. The circular disc shown in its plan view in Fig. 3.42 rotates in a plane parallel to the horizontal plane about the point O at a uniform angular velocity ω. Two other points A and B are located on the line OZ at distances r_A and r_B and from O respectively. The acceleration of point B with respect to point A is a vector of magnitude
    (a) zero
    (b) $\omega^2(r_B - r_A)$ and direction same as the direction of motion of point B
    (c) $\omega^2(r_B - r_A)$ and direction opposite to the direction of motion of point B
    (d) $\omega^2(r_B - r_A)$ and direction being from Z to O

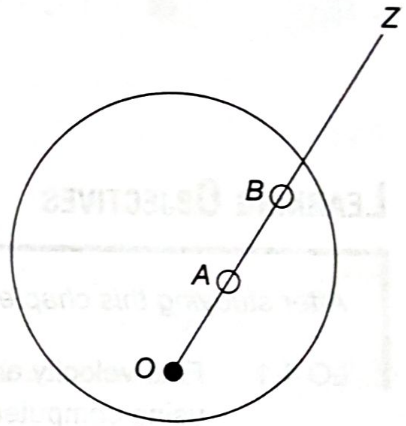

Fig. 3.42

Answers to Multiple-Choice Questions

1. (b)	2. (a)	3. (b)	4. (b)	5. (b)	6. (d)	7. (a)	8. (c)
9. (c)	10. (a)	11. (a)	12. (b)	13. (c)	14. (d)	15. (b)	16. (d)

Hints to Multiple-Choice Questions

12. $f_c = \omega^2 r = 16 \times 2 = 32$ m/s^2; $f_t = \alpha r = 12 \times 2 = 24$ m/s^2; Resultant acceleration = $\sqrt{32^2 + 24^2} = 40$ m/s^2.
13. There is no angular acceleration of the link and there is no linear acceleration of the sliding block. Thus there are centripetal and Coriolis components of acceleration.
    $f_c = \omega^2 r = 4 \times 1 = 4$ m/s^2; $f_{cr} = 2\omega v = 2 \times 2 \times 0.75 = 3$ m/s^2; Resultant acceleration = $\sqrt{4^2 + 3^2} = 5$ m/s^2.
14. Since the disc rolls without slip, there is no tangential component. Thus there is only a radial component of acceleration, i.e., $r\omega^2$.

Multiple-Choice Questions

1. Analytical methods to find velocity and acceleration are the most suitable for
   (a) manual calculations (b) desk-calculator
   (c) digital computer (d) none of these
2. For analytical solution of mechanisms, _____ links are considered as vectors.
   (a) moving links (b) fixed links
   (c) all (d) input and output
3. Coupler curves are the loci of a point on a _____ link.
   (a) coupler (b) output
   (c) input (d) any
4. The number of coupler curves which can be drawn in a mechanism can be
   (a) infinite (b) one
   (c) equal to number of links (d) depends on the motion of links.

Answers to Multiple-Choice Questions

1. (c) 2. (c) 3. (a) 4. (a)

Multiple-Choice Questions

1. Relative pole of moving link is its centre of rotation relative to a ______.
   (a) fixed link
   (b) moving link
   (c) any link
   (d) none of these
2. Freudenstein's equation is written in the following form:
   (a) $k_1 \cos \varphi + k_2 \cos \theta + k_3 - \cos (\theta - \varphi) = 0$
   (b) $k_1 \cos \varphi + k_2 \cos \theta + k_3 + \cos (\varphi - \theta) = 1$
   (c) $k_1 \cos \varphi + k_2 \cos \theta + k_3 - \cos (\theta - \varphi) = 1$
   (d) none of these
3. Function generation means designing a mechanism in which ______ are related by a function.
   (a) input and coupler links
   (b) output and coupler links
   (c) output and input links
   (d) none of these

Answers to Multiple-Choice Questions

1. (b)   2. (a)   3. (c)

Multiple-Choice Questions

1. A pantograph consists of
   (a) 4 links (b) 6 links
   (c) 8 links (d) 10 links
2. A Hart mechanism uses
   (a) 4 links (b) 6 links
   (c) 8 links (d) 10 links
3. A Paucellier mechanism has
   (a) 4 links (b) 6 links
   (c) 8 links (d) 10 links
4. Which of these mechanisms gives an approximately straight line?
   (a) Hart (b) Watt
   (c) Paucellier (d) Kempe

5. Which of these mechanisms has six links?
   (a) Tchebicheff
   (b) Hart
   (c) Paucellier
   (d) Watt
6. Which of these mechanisms use two identical mechanisms?
   (a) Hart
   (b) Watt
   (c) Paucellier
   (d) Kempe
7. Which of the following mechanisms using lower pairs is an exact straight-line mechanism?
   (a) Watt
   (b) Tchebicheff
   (c) Grasshopper
   (d) Paucellier
8. Davis steering gear is not used because
   (a) it has turning pairs
   (b) it is costly
   (c) it has sliding pairs
   (d) it does not fulfil the condition of correct gearing
9. Davis steering gear fulfils the condition of correct gearing at
   (a) one position
   (b) two positions
   (c) three positions
   (d) all positions
10. Ackermann steering gear fulfils the condition of correct gearing at
   (a) one position
   (b) two positions
   (c) three positions
   (d) all positions
11. A Hooke's joint is used to join two shafts which are
   (a) aligned
   (b) intersecting
   (c) parallel
   (d) skew
12. Maximum velocity of the driven shaft of a Hooke's joint is
   (a) $\omega_1 \cos a$
   (b) $\omega_1/\cos a$
   (c) $\omega_1 \sin a$
   (d) $\omega_1/\sin a$
13. Maximum velocity of the driven shaft of a Hooke's joint is at θ equal to
   (a) 0° and 180°
   (b) 90° and 270°
   (c) 90° and 180°
   (d) 180° and 270°

Answers to Multiple-Choice Questions

1. (a)	2. (b)	3. (c)	4. (b)	5. (b)	6. (d)	7. (d)	8. (c)
9. (d)	10. (c)	11. (b)	12. (b)	13. (a)			

Multiple-Choice Questions

1. The cam follower used in automobile engines is
   (a) roller (b) flat-faced
   (c) spherical-faced (d) knife-edged
2. In a radial cam, the follower moves in a direction
   (a) parallel to cam axis (b) perpendicular to cam axis
   (c) along the cam axis (d) none of these
3. The cam follower used in air-craft engines is _______ follower.
   (a) roller (b) flat-faced
   (c) spherical-faced (d) knife-edged
4. The reference point on the follower to lay the cam profile is known as the
   (a) cam centre (b) pitch point
   (c) trace point (d) prime point
5. The circle drawn to the cam profile with the minimum radius is called the
   (a) prime circle (b) cam circle
   (c) pitch circle (d) base circle
6. The size of the cam depends on
   (a) pitch circle (b) prime circle
   (c) base circle (d) pitch curve
7. The angle between axis of the follower and normal to pitch curve is known as
   (a) base angle (b) pressure angle
   (c) pitch angle (d) prime angle
8. The pressure angle of the cam _______ with increase in the base circle diameter.
   (a) decreases (b) increases
   (c) does not change (d) may decrease or increase
9. The point on the cam with maximum pressure angle is known as the
   (a) cam centre (b) pitch point
   (c) trace point (d) prime point
10. The most suitable follower motion programme for high-speed engine is
    (a) uniform acceleration and deceleration (b) uniform velocity
    (c) simple harmonic motion (d) cycloidal
11. In a cam follower motion, the follower has constant acceleration when it moves with
    (b) simple harmonic motion (b) cycloidal motion
    (c) parabolic motion (d) polynomial motion
12. The circle drawn to the pitch curve with the minimum radius from centre of rotation is called the
    (a) prime circle (b) cam circle
    (c) pitch circle (d) base circle
13. The locus of the trace point if the follower is moved around the cam is known as
    (a) prime circle (b) cam circle
    (c) pitch curve (d) base circle

14. In a cam-follower mechanism, the follower needs to rise through 20 mm during 60° of cam rotation, the first 30° with a constant acceleration and then with a deceleration of the same magnitude. The initial and final speeds of the follower are zero. The cam rotates at a uniform speed of 300 rpm. The maximum speed of the follower is
    (a) 0.60 m/s
    (b) 1.20 m/s
    (c) 1.68 m/s
    (d) 2.40 m/s
15. Consider a rotating disc cam and a translating roller follower with zero offset. Which one of the following pitch curves, parameterized by t, lying in the interval zero to 2π, is associated with the maximum translation of the follower during one full rotation of the cam rotating about the centre at $(x, y) = (0, 0)$?
    (a) $x(t) = \cos t,\ y(t) = \sin t$
    (b) $x(t) = \cos t,\ y(t) = 2\sin t$
    (c) $x(t)=\frac{1}{2}+\cos t, y(t)=2\sin t$
    (d) $x(t)=\frac{1}{2}+\cos t, y(t)=\sin t$
16. In an experiment to find the velocity and acceleration of a particular cam rotating at 10 rad/s, the values of displacements and velocities are recorded. The slope of displacement curve at an angle is 1.5 m/s and the slope of velocity curve at the same angle is –0.5 m/s^2. The velocity and acceleration of the cam at the instant are respectively.
    (a) 15 m/s and –5 m/s^2
    (b) 15 m/s and 5 m/s^2
    (c) 1.2 m/s and –0.5 m/s^2
    (d) 1.2 m/s and 0.5 m/s^2
17. In a plate cam mechanism with reciprocating roller follower, the follower has a constant acceleration in the case of
    (a) cycloidal motion
    (b) simple harmonic motion
    (c) parabolic motion
    (d) 3-4-5 polynomial motion

Answers to Multiple-Choice Questions

1. (c)	2. (b)	3. (a)	4. (c)	5. (d)	6. (c)	7. (b)
8. (a)	9. (b)	10. (d)	11. (c)	12. (a)	13. (c)	14. (b)
15. (c)	16. (a)	17. (c)				

Hints to Multiple-Choice Questions

14. Use Eq. (7.8); $v_{max} = \dfrac{2\,\omega}{\varphi} = \dfrac{2\times 0.02\times(2\pi\times 300/600)}{60\pi/180} = 1.2$ m/s.

15. Considering various values of angle lying between 0 and 2π, It is observed (c) provides maximum translation of the follower. The maximum values are x = 1/2 and y = 2 at angle $\pi/2$.

16. $v=\dfrac{ds}{dt}=\dfrac{ds}{d\theta}\cdot\dfrac{d\theta}{dt}=1.5\times 10=15$ m/s; Acceleration $=\dfrac{dv}{dt}=\dfrac{dv}{d\theta}\cdot\dfrac{d\theta}{dt}=-0.5\times 10=-5$ m/s^2.

Multiple-Choice Questions

1. The efficiency of a screw jack depends on
   (a) pitch of threads
   (b) load
   (c) both pitch and load
   (d) neither pitch nor load
2. The efficiency of a screw jack increases with
   (a) decrease in load
   (b) increase in load
   (c) decrease in pitch
   (d) increase in pitch

3. The efficiency of a screw jack is

(a) $\eta = \dfrac{\tan\alpha}{\tan(\alpha-\varphi)}$ (b) $\eta = \dfrac{\tan(\alpha+\varphi)}{\tan\alpha}$

(c) $\eta = \dfrac{\tan\alpha}{\tan(\alpha+\varphi)}$ (d) $\eta = \dfrac{\tan(\alpha-\varphi)}{\tan\alpha}$

4. The efficiency of a screw jack is maximum when

(a) $\alpha = 45° - \dfrac{\varphi}{4}$ (b) $\alpha = 45° + \dfrac{\varphi}{2}$

(c) $\alpha = 45° + \dfrac{\varphi}{4}$ (d) $\alpha = 45° - \dfrac{\varphi}{2}$

5. The maximum efficiency of a screw jack is given by

(a) $\eta = \dfrac{1+\sin\varphi}{1-\sin\varphi}$ (c) $\eta = \dfrac{1-\sin\varphi}{1+\sin\varphi}$

(c) $\eta = \dfrac{1+\sin\varphi}{1-\cos\varphi}$ (d) $\eta = \dfrac{1+\sin\varphi}{1-\cos\varphi}$

6. The efficiency of a wedge is

(a) $\eta = \dfrac{\tan\alpha}{\tan(\alpha-2\varphi)}$ (b) $\eta = \dfrac{\tan(\alpha+2\varphi)}{\tan\alpha}$

(c) $\eta = \dfrac{\tan\alpha}{\tan(\alpha+2\varphi)}$ (d) $\eta = \dfrac{\tan(\alpha-2\varphi)}{\tan\alpha}$

7. In a flat collar bearing, the moment due to friction with uniform pressure is proportional to

(a) $\dfrac{(R_o^3-R_i^3)}{(R_o^2-R_i^2)}$ (b) $\dfrac{(R_o^3-R_i^3)}{(R_o-R_i)}$

(c) $\dfrac{(R_o^2-R_i^2)}{(R_o-R_i)}$ (d) $\dfrac{(R_o^2-R_i^2)}{(R_o^3-R_i^3)}$

8. In a flat pivot bearing, the moment due to friction with uniform pressure is assumed to act at

(a) r (b) $r/2$

(c) $r/3$ (d) $2r/3$

9. In a flat pivot bearing, assuming uniform wear, the frictional torque transmitted is

(a) μFR (b) $\dfrac{1}{2}\mu FR$

(c) $\dfrac{2}{3}\mu FR$ (d) $\dfrac{3}{4}\mu FR$

10. No force is required for downward motion of a load on a screw jack if

(a) $\alpha < \varphi$ (b) $\alpha > \varphi$

(c) $\alpha > 2\varphi$ (d) $\alpha < 2\varphi$

11. For flat and conical pivots, ratio of friction torque with uniform wear to friction torque with uniform pressure is

(a) 2/3 (b) 3/2

(c) 4/3 (d) 3/4

12. The frictional torque for the same diameter in a conical bearing is ______ than in a flat bearing.

(a) more (b) less

(c) equal (d) may be more or less

13. In a multiple friction clutch, the number of active friction surfaces is
    (a) $2n$
    (b) n
    (c) $2(n-1)$
    (d) $n-1$
14. For a safe design, a friction clutch is designed assuming
    (a) uniform pressure theory
    (b) uniform wear theory
    (c) any one of the two
    (d) none of these
15. The radius of a friction circle drawn for a journal rotating in a bearing depends on the coefficient of friction and ____.
    (a) angular velocity of the journal
    (b) radius of the journal
    (c) clearance between the journal and the bearing
    (d) weight of the shaft

Answers to Multiple-Choice Questions

1. (a)	2. (d)	3. (c)	4. (d)	5. (b)	6. (c)	7. (a)	8. (d)
9. (b)	10. (b)	11. (d)	12. (a)	13. (d)	14. (b)	15. (b)	

Multiple-Choice Questions

1. Which of the following is not a flexible type of connectors?
   (a) Belt (b) Rope
   (c) Chain (d) Gear
2. In an open or crossed-belt drive, the velocity ratio of the two pulleys is
   (a) directly proportional to their diameters
   (b) directly proportional to the square of their diameters
   (c) inversely proportional to their diameters
   (d) inversely proportional to the square of their diameters
3. A pulley and belt in a belt drive constitutes a
   (a) turning pair (b) sliding pair
   (c) cylindrical pair (d) rolling pair
4. Due to slip, the velocity ratio of a belt drive
   (a) increases (b) decreases
   (c) remains same (d) none of these
5. The included angle of a pulley for V belt is
   (a) 50° – 60° (b) 30° – 40°
   (c) 20° – 30° (d) 40° – 50°
6. The crowning of pulleys is done to
   (a) increase the tightness of belt on the pulley
   (b) to prevent belt running off the pulley
   (c) to increase the torque transmitted
   (d) to improve the shape and strength of the pulley
7. The law of belting states that the centre line of the belt when it ______ a pulley must lie in the mid-plane of that pulley.
   (a) leaves (b) approaches
   (c) approaches as well as leaves (d) none of these
8. For maximum power transmission by a belt drive, the maximum tension must be
   (a) $2T_c$ (b) $3T_c$
   (c) $4T_c$ (d) $5T_c$
9. For maximum power transmission, the velocity of the belt is
   (a) $\dfrac{T}{\sqrt{m}}$ (b) $\dfrac{T}{\sqrt{2m}}$
   (c) $\dfrac{T}{\sqrt{3m}}$ (d) $\dfrac{T}{\sqrt{4m}}$

10. The belt drive is designed on the basis of angle of contact on the
    (a) larger pulley
    (b) smaller pulley
    (c) any pulley
    (d) none of these
11. The ratio of tight and slack side tensions in a V-belt or rope is
    (a) $e^{\mu\theta \sin\alpha}$
    (b) $e^{\mu\theta/\cos\alpha}$
    (c) $e^{\mu\theta \cos\alpha}$
    (d) $e^{\mu\theta/\sin\alpha}$
12. An increase in the initial tension in the belt ____ the power transmitted.
    (a) increases
    (b) decreases
    (c) does not effect
    (d) none of these

Answers to Multiple-Choice Questions

1. (d)	2. (c)	3. (d)	4. (b)	5. (b)	6. (b)	7. (b)	8. (b)
9. (c)	10. (b)	11. (d)	12. (a)				

Multiple-Choice Questions

1. Two parallel shafts can be connected by ______ gears.
   (a) straight spur (b) spiral
   (c) cross-helical (d) straight bevel
2. Two intersecting shafts can be connected by ______ gears.
   (a) straight spur (b) spiral
   (c) cross-helical (d) straight bevel
3. Two parallel shafts cannot be connected by ______ gears.
   (a) spur (b) helical
   (c) herringbone (d) bevel
4. Two skew shafts can be connected by ______ gears.
   (a) straight spur (b) spiral bevel
   (c) cross-helical (d) straight bevel
5. The size of gears is usually specified by
   (a) circular pitch (b) outside diameter
   (c) pitch circle diameter (d) inside diameter
6. Mitre gears are
   (a) spur gears with gear ratio 1
   (b) helical gears with speed ratio 1
   (c) bevel gears with gear ratio 1 and angle between shafts 90°
   (d) gears for non-parallel and non-intersecting shafts
7. In single-throated worm gears, there is ______ contact between the teeth.
   (a) point (b) line
   (c) area (d) any of these
8. In double-throated worm gears, there is ______ contact between the teeth.
   (a) point (b) line
   (c) area (d) any of these
9. Crossed-helical gears are suitable for ______ loads.
   (a) light (b) medium
   (c) heavy (d) any type of load
10. Standard value of addendum in gears is ______ module.
    (a) 1 (b) 2
    (c) 1.157 (d) 2×1.157
11. Standard value of dedendum in gears is ______ module.
    (a) 1 (b) 2
    (c) 1.157 (d) 2×1.157
12. The circular pitch of spur gears is the ratio of
    (a) the number of teeth to the pitch diameter
    (b) the pitch diameter to the number of teeth
    (c) the circumference of pitch circle to number of teeth
    (d) the circumference of pitch circle to diameter of pitch circle
13. The module of spur gears is the ratio of
    (a) the number of teeth to the pitch diameter
    (b) the pitch diameter to the number of teeth
    (c) the circumference of pitch circle to number of teeth
    (d) the circumference of pitch circle to diameter of pitch circle

14. The pressure angle of spur gears is kept small
    (a) to reduce axial thrust on the bearings
    (b) to increase the force for power transmission
    (c) for both (a) and (b)
    (d) none of (a) and (b)
15. The contact ratio of gears is always
    (a) more than one
    (b) one
    (c) less than one
    (d) zero
16. An imaginary circle which by pure rolling action, provides the same motion as the actual gear is known as
    (a) pitch circle
    (b) addendum circle
    (c) dedendum circle
    (d) base circle
17. For involute gear system, if s is the distance between the point of contact and the pitch point and ω_1 and ω_2 are the angular velocities of the meshing gears, the velocity of sliding is given by
    (a) $(\omega_1 + \omega_2)\, s/2$
    (b) $(\omega_1 + \omega_2)\, 2s$
    (c) $(\omega_1 \times \omega_2)\, s$
    (d) $(\omega_1 + \omega_2)\, s$
18. Value of pressure angle generally used for involute gears is
    (a) 20°
    (b) 25°
    (c) 30°
    (d) 35°
19. To have a velocity ratio of 50, the appropriate gears will be
    (a) spur gears
    (b) helical gears
    (c) worm and worm wheel
    (d) bevel gears
20. For an involute gear system, the sliding velocity
    (a) is zero at the pitch point
    (b) is zero at the point of engagement
    (c) is zero at the point of disengagement
    (d) depends upon gear ratio
21. In case of involute gear teeth, the pressure angle is
    (a) same at all points of contact
    (b) maximum at the engagement of teeth
    (c) minimum at the engagement of teeth
    (d) zero at the pitch point.
22. The ratio of circular pitch and the module is
    (a) π
    (b) $1/\pi$
    (c) π^2
    (d) $1/\pi^2$
23. The path of contact in involute tooth profiles is a
    (a) parabola
    (b) circle
    (c) straight line
    (d) curve
24. Interference occurs in case of
    (a) cycloidal profile teeth
    (b) involute profile teeth
    (c) in both of them
    (d) none of these
25. Minimum number of teeth in rack and pinion for 20° pair angle teeth is
    (a) 20
    (b) 18
    (c) 22
    (d) 24
26. In spur gears, the circle on which the involute is generated is known as
    (a) pitch circle
    (b) clearance circle
    (c) dedendum circle
    (d) base circle
27. The normal circular pitch in helical gears is given by
    (a) $p \sin \psi$
    (b) $p/\sin \psi$
    (c) $p \cos \psi$
    (d) $p/\cos \psi$
28. Maximum efficiency of spiral gears is given by
    (a) $\dfrac{\cos(\theta - \varphi) + 1}{\cos(\theta + \varphi) + 1}$
    (b) $\dfrac{\cos(\theta + \varphi) - 1}{\cos(\theta - \varphi) + 1}$
    (c) $\dfrac{\cos(\theta + \varphi) + 1}{\cos(\theta - \varphi) - 1}$
    (d) $\dfrac{\cos(\theta + \varphi) + 1}{\cos(\theta - \varphi) + 1}$

29. Maximum efficiency of worm and worm wheel is given by
(a) $\frac{1-\sin\varphi}{1+\sin\varphi}$ (b) $\frac{1+\sin\varphi}{1-\sin\varphi}$
(c) $\frac{1-\cos\varphi}{1+\sin\varphi}$ (d) $\frac{1-\sin\varphi}{1+\cos\varphi}$

30. The curve traced by a point on the circumference of a circle rolling inside another fixed circle is known as
(a) involute (b) cycloid
(c) epicycloids (d) hypocycloid

31. In case of involute gear teeth, the pressure angle
(a) is always constant (b) always varies
(c) depends on the size of the teeth (d) depends on the speed of gears

32. Which of the following statements is correct for involute gears?
(a) A convex flank is always in contact with a concave flank
(b) Interference is inherently not present
(c) Variation in centre distance of shafts varies radial force
(d) Pressure angle is constant during the teeth engagement

33. A pinion drives a gear. Both have the same size of addendum. The interference can occur between
(a) tip of pinion and flank of gear (b) tip of gear and flank of pinion
(c) tips of both pinion and gear (d) flanks of both pinion and gear

34. In involute gears, tooth profile starts from
(a) pitch circle (b) addendum circle
(c) dedendum circle (d) base circle

35. The motion between the teeth of two spur gears in mesh is generally
(a) rotary (b) sliding
(c) rolling (d) sliding as well as rolling

36. The line of action of two spur gears in mesh is tangential to
(a) pitch circle (b) addendum circle
(c) dedendum circle (d) base circle

37. In involute gear teeth drive, the contact begins at the intersection of
(a) line of action and the pitch circle of the driven gear
(b) line of action and the pitch circle of the driving gear
(c) line of action and the addendum circle of the driven gear
(d) dedendum circle of the of driven gear and the addendum circle of the driving gear

38. For an involute gear system, a slight increase in the centre distance between two mating gears results in
(a) interference of gears (b) pressure angle increase
(c) pressure angle decrease (d) no effect

39. Two spur gears in mesh have 30 teeth and 90 teeth. The pinion rotates at 800 rpm and transmits a torque of 30 N.m. The torque transmitted by the gear is
(a) 30 N.m (b) 60 N.m
(c) 90 N.m (d) 120 N.m

40. Tooth interference in an external involute spur gear pair can be reduced by
(a) decreasing centre distance between gear pair (b) decreasing module
(c) decreasing pressure angle (d) increasing number of gear teeth

41. A spur pinion of pitch diameter 50 mm rotates at 200 rad/s and transmits 3 kW power. The pressure angle of the tooth of the pinion is 20°. Assuming that only one pair of the teeth is in contact, the total force exerted by a tooth of the pinion on the tooth on a mating gear is ______N.

42. A pair of spur gears with module 5 mm and a centre distance of 450 mm is used for a speed reduction of 5:1. The number of teeth on pinion is ____ .

Multiple-Choice Questions

1. In a simple gear train, if there is odd number of idlers, the direction of rotation of the driver and the driven gears will be
   (a) opposite (b) same
   (c) depends upon number of teeth of the gears (d) none of these
2. In a reverted gear train, the axes of the first and last gear are
   (a) parallel (b) co-axial
   (c) skew (d) perpendicular to each other

3. The train value in case of compound gear train is given by
   (a) $\dfrac{\text{product of number of teeth on drivers}}{\text{product of number of teeth on followers}}$
   (b) $\dfrac{\text{product of number of teeth on followers}}{\text{product of number of teeth on drivers}}$
   (c) $\dfrac{\text{number of teeth on last follower}}{\text{number of teeth on first driver}}$
   (d) $\dfrac{\text{number of teeth on first driver}}{\text{number of teeth on last follower}}$
4. If the axes of first and last gear of a gear train are co-axial, the gear train is known as
   (a) simple (b) epicyclic
   (c) reverted (d) compound
5. In a simple gear train, the train value is given by
   (a) $\dfrac{N_1}{N_n}$ (b) $\dfrac{N_n}{N_1}$
   (c) $N_1 \times N_n$ (d) $N_n - N_1$
6. Speed ratio of a gear train is
   (a) equal to train value (b) reciprocal of train value
   (c) not related to train value (d) none of these
7. A gear train in which axes of gears have motion are called ____ gear trains.
   (a) epicyclic (b) simple
   (c) compound (d) reverted
8. In a clock mechanism, hour and minute hands are connected by ____ gear train.
   (a) simple (b) epicyclic
   (c) compound (d) reverted
9. A fixed gear having 200 teeth meshes with a pinion having 50 teeth. The two are connected by an arm. What is the number of turns made by pinion for one complete revolution of the arm about the centre of the gear?
   (a) 2 (b) 3
   (c) 4 (d) 5
10. Annular wheel of an epicyclic gear train has 80 teeth. If the planet wheel has 16 teeth, the sun wheel has ______ teeth.
   (a) 24 (b) 48
   (c) 64 (d) 72
11. A differential uses____ gear train.
   (a) simple (b) epicyclic
   (c) reverted (d) compound
12. The two gears A and B of an epicyclic gear train are of equal size. Gear A is fixed. The arm revolves about the centre of gear A with an angular velocity of 3 rad/s. The angular velocity of gear B is ______ rad/s.
   (a) 3 (b) 6
   (c) 9 (d) 12
13. A planetary gear train is also known as ________ gear train.
   (a) simple (b) compound
   (c) reverted (d) epicyclic
14. The number of degrees of freedom of the planetary gear train shown in Fig. 11.33 is
   (a) 0 (b) 1
   (c) 2 (d) 3

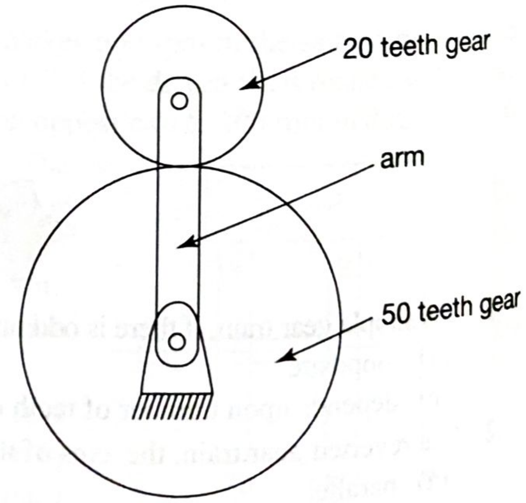

Fig. 11.33

15. In Fig. 11.34, Gear 2 rotates at 1200 rpm in counter clockwise direction and engages with Gear 3. Gear 3 and Gear 4 are mounted on the same shaft. Gear 5 engages with Gear 4. The numbers of teeth on Gears 2, 3, 4 and 5 are 20, 40, 15 and 30, respectively. The angular speed of Gear 5 is
    (a) 300 rpm ccw
    (b) 300 rpm cw
    (c) 4800 rpm ccw
    (d) 4800 rpm cw

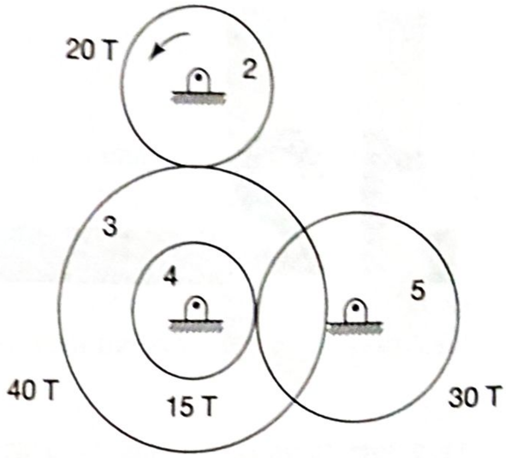

Fig. 11.34

16. A gear train is made up of five spur gears as shown in Fig. 11.35. Gear 2 is driver and gear 6 is driven member. N_2, N_3, N_4, N_5 and N_6 represent number of teeth on gears 2, 3, 5 and 6 respectively. The gear(s) which act(s) as idler(s) is/are
    (a) only 3
    (b) only 4
    (c) only 5
    (d) both 3 and 5

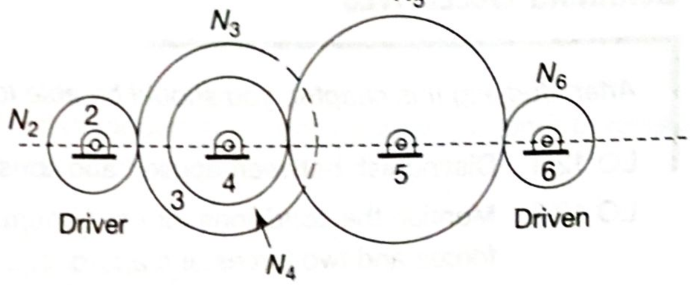

Fig. 11.35

17. A compound gear train with gears P, Q, R and S has number of teeth 20, 40, 15 and 20, respectively. Gears Q and R are mounted on the same shaft as shown in Fig. 11.36. The diameter of the gear Q is twice that of the gear R. If the module of the gear R is 2 mm, the centre distance between gears P and S is ______ mm.

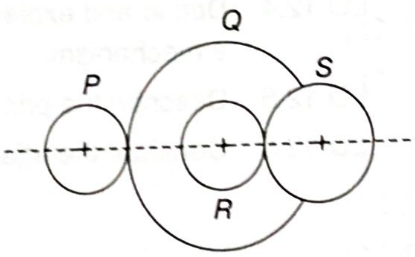

Fig. 11.36

Answers to Multiple-Choice Questions

1. (b) 2. (b) 3. (a) 4. (c) 5. (b) 6. (b) 7. (a)
8. (d) 9. (d) 10. (b) 11. (b) 12. (b) 13. (d) 14. (c)
15. (a) 16. (c) 17. 80

Hints to Multiple-Choice Questions

14. Eq. (1.2), $N = 4$, There are three pairs with one DOF and one pair with one DOF.
    Thus, degrees of freedom $= 3(4-1) - 2 \times 3 - 1 \times 1 = 2$.

15. $\dfrac{N_5}{N_2} = \dfrac{N_2 \times N_4}{N_3 \times N_5} = \dfrac{20 \times 15}{40 \times 30} = 0.25$ or $N_5 = 0.25 \times 1200 = 300$ rpm ccw

16. $\dfrac{N_6}{N_2} = \dfrac{N_2 \times N_4 \times N_5}{N_3 \times N_5 \times N_6} = \dfrac{N_2 \times N_4}{N_3 \times N_6}$; Thus only gear 5 is idle.

17. $D_r = 15 \times 2 = 30$ mm; $D_q = 30 \times 2 = 60$ mm; $D_p = 60 \times 20/40 = 30$ mm; $D_s = 30 \times 20/15 = 40$ mm;

    Centre distance between gears P and $S = \dfrac{30+60}{2} + \dfrac{30+40}{2} = 80$ mm

Multiple-Choice Questions

1. A pair of action and reaction forces acting on a body are known as
   (a) applied forces
   (b) constraint forces
   (c) accelerating forces
   (d) inertia forces
2. In static equilibrium, the vector sum of all the forces acting on the body and all the moments about ______ point is zero.
   (a) a fixed
   (b) a particular
   (c) any arbitrary
   (d) a permanent
3. If the lines of action of three or more forces intersect at a point, it is known as the ______ point.
   (a) equilibrium
   (b) central
   (c) zero
   (d) concurrency
4. A part isolated from the mechanism ______ be in equilibrium.
   (a) may
   (b) may or may not
   (c) must
   (d) none of these

Answers to Multiple-Choice Questions

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

Multiple-Choice Questions

1. Acceleration of piston of a reciprocating engine is _____.

   (a) $r\omega^2\left(\sin\theta + \frac{\sin 2\theta}{n}\right)$
   (b) $r\omega\left(\cos\theta + \frac{\cos 2\theta}{n}\right)$
   (c) $r\omega^2\left(\cos\theta + \frac{\cos 2\theta}{4n}\right)$
   (d) $r\omega^2\left(\cos\theta + \frac{\cos 2\theta}{n}\right)$

2. Crank effort is the net force applied at the crankpin _______ to the crank which gives the required turning moment on the crankshaft.

   (a) parallel
   (b) perpendicular
   (c) at 45°
   (d) 135°

3. In a dynamically equivalent system, a uniformly distributed mass is divided into ______ point masses.

   (a) two
   (b) three
   (c) four
   (d) five

4. Any distributed mass can be replaced by two point masses to have the same dynamical properties if

   (a) the sum of the two masses is equal to the total mass
   (b) the combined centre of mass coincides with that of the rod
   (c) the moment of inertia of two point masses about perpendicular axis through their combined centre of mass is equal to that of the rod
   (d) all of above

5. In a slider crank mechanism, if θ and β are the angles made by the crank and the connecting rod respectively with the line of stroke and v is the linear velocity of the crankpin, the velocity of slider is given by

   (a) $v \cos [90° - (\theta - \beta)] \cos \beta$
   (b) $v \cos [90° + (\theta - \beta)] \cos \beta$
   (c) $v \cos [90° - (\theta + \beta)] \sin \beta$
   (d) $v \cos [90° - (\theta + \beta)] \cos \beta$

6. Which of the following is not the required condition for replacing a rigid body by a dynamically equivalent system of two masses?
   (a) The sum of the two masses is equal to the total mass.
   (b) The sum of the squares of two masses is equal to square of the total mass.
   (c) The combined centre of mass coincides with that of the rod.
   (d) The moment of inertia of two point masses about perpendicular axis through their combined centre of mass is equal to that of the rod.
7. The maximum fluctuation of energy is the
   (a) ratio of maximum and minimum energies
   (b) sum of maximum and minimum energies
   (c) difference of maximum and minimum energies
   (d) difference of maximum and minimum energies from mean energy
8. The maximum fluctuation of energy in a flywheel is equal to
   (a) $I\omega(\omega_1 - \omega_2)$ (b) $I\omega^2 K$
   (c) $2KE$ (d) All
   (e) none
9. A machine requires a torque of $(300 + 50 \sin 2\theta)$ to drive it. It is directly coupled to an engine producing a torque of $(300 + 50 \sin \theta)$ in a cycle. How many times the values of torque of the machine and the engine will be the same?
   (a) 1 (b) 2
   (c) 4 (d) 8
10. If a mean radius of a rim-type flywheel is halved, its stored energy is _____ of the original flywheel at the same speed.
   (a) Two times (b) half
   (c) same as (d) one-fourth
11. In a slider-crank mechanism, the connecting rod has zero angular velocity when the crank angle is
   (a) 0° (b) 45°
   (c) 90° (d) 180°
12. The amount of energy absorbed by a flywheel is found from
   (a) Speed-energy diagram (b) velocity-crank angle diagram
   (c) acceleration-crank angle diagram (d) torque-crank angle diagram
13. If K is the coefficient of fluctuation of speed and E is the kinetic energy of the flywheel at mean speed, the maximum fluctuation of energy is equal to
   (a) EK (b) $EK/2$
   (c) $2EK$ (d) $2EK^2$
14. In a certain slider-crank mechanism, lengths of crank and connecting rod are equal. If the crank rotates with a uniform angular speed of 14 rad/s and the crank length is 300 mm, the maximum acceleration of the slider is ______ m/s^2.
15. A slider-crank mechanism with crank radius 200 mm and connecting rod length 800 mm is shown in Fig. 13.36. The crank is rotating at 600 rpm in the counter-clockwise direction. In the configuration shown, the crank makes an angle of 90° with the sliding direction of the slider, and a force of 5 kN is acting on the slider. Neglecting the inertia forces, the turning moment on the crank is________ kN.m.

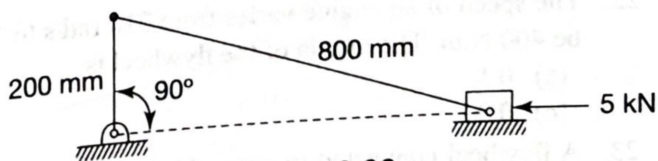

Fig. 13.36

16. The earth can be assumed as a uniform sphere. Suppose the earth shrinks by 1% in diameter, the new day period
    (a) will not change from 24 hours
    (b) will reduce by about 2%
    (c) will reduce by about 1%
    (d) will increase by about 1%
17. The cross-head velocity in the slider-crank mechanism, for the position shown in Fig. 13.37 is
    (a) $V_c \cos\left(90^\circ - \overline{\alpha + \beta}\right)\cos\beta$
    (b) $V_c \cos\left(90^\circ - \overline{\alpha + \beta}\right)\sec\beta$
    (c) $V_c \cos\left(90^\circ - \overline{\alpha - \beta}\right)\cos\beta$
    (d) $V_c \cos\left(90^\circ - \overline{\alpha - \beta}\right)\sec\beta$

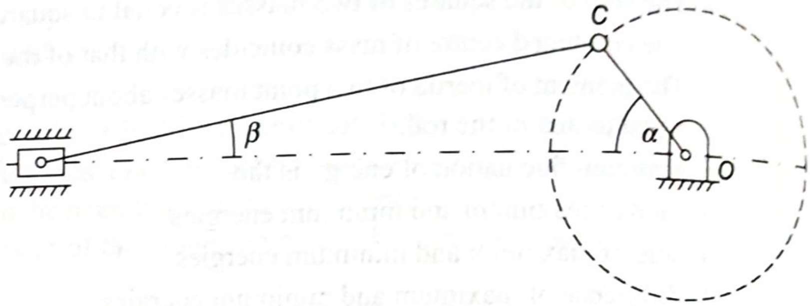

Fig. 13.37

18. Maximum fluctuation of kinetic energy in an engine has been calculated to be 2600 J. Assuming that the engine runs at an average speed of 200 rpm, the polar mass moment of inertia of a flywheel to keep the speed fluctuation within ±0.5% of the average speed is ___ kg.m^2.
19. A flywheel of moment of inertia 9.8 kg m^2 fluctuates by 30 rpm for a fluctuation in energy of 1936 J. The mean speed of the flywheel is _____ rpm.
    (a) 600
    (b) 900
    (c) 968
    (d) 2940
20. For a certain engine having an average speed of 1200 rpm, a flywheel approximated as a solid disc, is required for keeping the fluctuation of speed within 2% about the average speed. The fluctuation of kinetic energy per cycle is found to be 2 kJ. What is the least possible mass of the flywheel if its diameter is not to exceed 1 m?
    (a) 40 kg
    (b) 51 kg
    (c) 62 kg
    (d) 73 kg
21. Torque and angular speed data over one cycle for a shaft carrying a flywheel are shown in Figs 13.38(a) and (b). The moment of inertia of the flywheel is _____ kg.m^2.

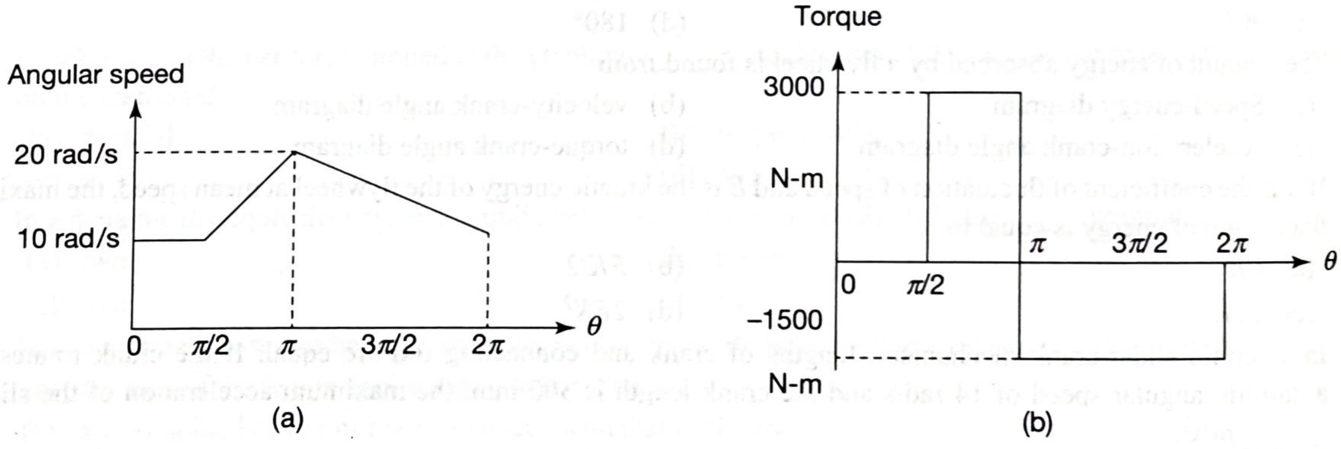

Fig. 13.38

22. The speed of an engine varies from 210 rad/s to 190 rad/s. During a cycle the change in kinetic energy is found to be 400 N.m. The inertia of the flywheel is _____ kg.m^2.
    (a) 0.1
    (b) 0.2
    (c) 0.3
    (d) 0.4
23. A flywheel connected to a punching machine has to supply energy of 400 N.m while running at a mean angular speed of 20 rad/s. If the total fluctuation of speed is not to exceed ±2%, the mass moment of inertia of the flywheel is ____ kg.m^2.
    (a) 25
    (b) 50
    (c) 100
    (d) 125

24. If K is the coefficient of speed fluctuation of a flywheel then the ratio of $\omega_{max}/\omega_{min}$ will be

(a) $\dfrac{1-2K}{1+2K}$ (b) $\dfrac{2-K}{2+K}$

(c) $\dfrac{1+2K}{2-2K}$ (d) $\dfrac{2+K}{2-K}$

25. A circular solid disc of uniform thickness 20 mm, radius 200 mm and mass 20 kg is used as a flywheel. If it rotates at 600 rpm, the kinetic energy of the flywheel is ____Joules.

26. An annular disc has a mass m, inner radius R and outer radius $2R$. The disc rolls on a flat surface without slipping. If the velocity of the centre of mass is v, the kinetic energy of the disc is

(a) $\dfrac{9}{16}mv^2$ (b) $\dfrac{11}{16}mv^2$

(c) $\dfrac{13}{16}mv^2$ (d) $\dfrac{16}{16}mv^2$

Answers to Multiple-Choice Questions

1. (b)	2. (b)	3. (a)	4. (d)	5. (d)	6. (b)	7. (c)	8. (d)
9. (c)	10. (d)	11. (c)	12. (d)	13. (c)	14. 117.6	15. 1	16. (c)
17. (b)	18. 592.7	19. (a)	20. (b)	21. 31.4	22. (a)	23. (a)	24. (d)
25. 789	26. (c)						

Hints to Multiple-Choice Questions

14. Use Eq. (13.12), the max acceleration is when θ is zero. $n = 1$,
So, maximum acceleration $= 2r\omega^2 = 2 \times 0.3 \times 196 = 117.6$ m/s

15. Use Eq. (13.21), θ is 90°. So $T = Fr = 5 \times 0.2 = 1$ kN.m

16. KE of earth, $E = \dfrac{1}{2}I\omega^2 = \dfrac{1}{2}\left(\dfrac{2}{5}MR^2\right)\omega^2 = \dfrac{1}{20}MD^2\omega^2$

$$dE = \frac{M}{20}[D^2 2\omega d(\omega) + \omega^2 2Dd(D)]; \quad \frac{dE}{E} = \frac{2d(\omega)}{\omega} + \frac{2d(D)}{D}$$

For conservation of energy, $dE/E = 0$, $\dfrac{2d(D)}{D} = -\dfrac{2d(\omega)}{\omega}$, i.e., if diameter is reduced by 1%, speed increases by 1% and thus the day period is reduced by 1%.

17. If velocity of the cross head is V, the components of V and V_c along the axial direction of connecting rod must be same (Fig. 13.39), Thus,

$V\cos\beta = V_c\cos\left(90^\circ - \overline{\alpha+\beta}\right)$ or $V = V_c\cos\left(90^\circ - \overline{\alpha+\beta}\right)\sec\beta$

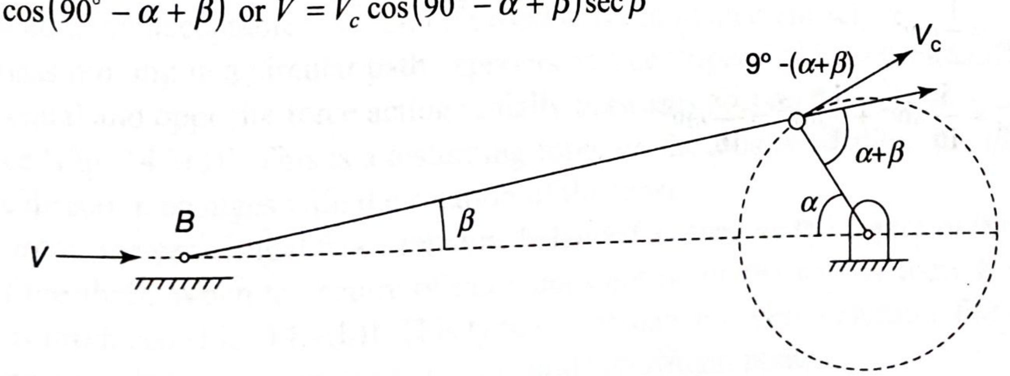

Fig. 13.39

18. $K = \dfrac{e}{I\omega^2}$ or $\dfrac{0.5+0.5}{100} = \dfrac{2600}{I(2\pi \times 200/60)^2}$ or $I = 592.7\ \text{kg.m}^2$

19. $K = \dfrac{e}{I\omega^2}$ or $\dfrac{2\pi \times 30/60}{\omega} = \dfrac{1936}{9.8\omega^2}$ or $\omega = 62.9\dfrac{\text{rad}}{s}$ or $N = 62.9 \times \left(\dfrac{60}{2\pi}\right)$ or 600 rpm

20. $K = \dfrac{e}{I\omega^2}$ or $0.02 = \dfrac{2000}{I(2\pi \times 1200/60)^2}$ or $I = 6.33$ or $mk^2 = 6.33$

$$m\left(\frac{r}{\sqrt{2}}\right)^2 = 6.33 \text{ or } m\left(\frac{0.5}{\sqrt{2}}\right)^2 = 6.33 \text{ or } m = 50.6\,\text{kg}$$

21. $\omega = \dfrac{20+10}{2} = 15\,\text{rad/s};\ K = \dfrac{20-10}{15} = \dfrac{2}{3};$

As the areas above and below θ-axis line are equal [Fig. 13.38(b)],

$$e = \frac{\pi}{2} \times 3000 = 1500\pi\ ;\ K = \frac{e}{I\omega^2} \text{ or } \frac{2}{3} = \frac{1500\pi}{I \times 15^2} \text{ or } I = 31.4\ \text{kg.m}^2$$

22. $\omega = \dfrac{210+190}{2} = 200\dfrac{\text{rad}}{\text{s}};\ K = \dfrac{210-190}{200} = 0.1;\ K = \dfrac{e}{I\omega^2} \text{ or } 0.1 = \dfrac{400}{I \times 200^2}$ or $I = 0.1\text{kg.m}^2$

23. $K = \dfrac{e}{I\omega^2} \text{ or } 0.04 = \dfrac{400}{I \times 20^2}$ or $I = 25\ \text{kg.m}^2$

24. $K = \dfrac{\omega_{max} - \omega_{min}}{\omega} = \dfrac{\omega_{max} - \omega_{min}}{(\omega_{max} + \omega_{min})/2}$ or $\dfrac{K}{2} = \dfrac{\omega_{max} - \omega_{min}}{\omega_{max} + \omega_{min}}$

$$\text{or } \frac{K+2}{K-2} = \frac{\omega_{max} - \omega_{min} + \omega_{max} + \omega_{min}}{\omega_{max} - \omega_{min} - \omega_{max} - \omega_{min}} \text{ or } \frac{K+2}{K-2} = -\frac{\omega_{max}}{\omega_{min}} \text{ or } \frac{\omega_{max}}{\omega_{min}} = \frac{2+K}{2-K}$$

25. $I = \dfrac{mr^2}{2} = \dfrac{20 \times 0.2^2}{2} = 0.4\text{kg.m}^2;\ \omega = \dfrac{2\pi \times 600}{60} = 62.8\text{rad/s};$

$$\text{Kinetic energy} = \frac{I\omega^2}{2} = \frac{0.4 \times 62.8^2}{2} = 789\ \text{J}$$

26. $I = \dfrac{m}{2}\left(r_i^2 + r_o^2\right) = \dfrac{m}{2}\left(R^2 + 4R^2\right) = \dfrac{5}{2}mR^2$

$$\text{KE}_{\text{rot}} = \frac{1}{2}I\omega^2 = \frac{1}{2}\left(\frac{5}{2}mR^2\right)\left(\frac{v}{2R}\right)^2 = \frac{5}{16}mv^2$$

$$\text{KE}_{\text{trans}} = \frac{1}{2}mv^2$$

$$\text{KE}_{\text{total}} = \frac{5}{16}mv^2 + \frac{1}{2}mv^2 = \frac{13}{16}mv^2$$

Multiple-Choice Questions

1. Static balancing involves balancing of
   (a) forces
   (b) couples
   (c) forces as well as couples
   (d) masses
2. In case of rotating masses, the magnitude of the balancing mass is ________ when the speed of the shaft is doubled.
   (a) doubled
   (b) halved
   (c) unaffected
   (d) quadrupled
3. For complete dynamic balance, at least ______ mass/masses are necessary.
   (a) two
   (b) three
   (c) four
   (d) one

4. If a rotating system is dynamically balanced, it is statically
   (a) balanced (b) unbalanced
   (c) partially balanced (d) none of these
5. The magnitude of the secondary force is ____ the primary force
   (a) more than (b) less than
   (c) equal to (d) none of these
6. In reciprocating engines, the primary unbalanced force
   (a) cannot be balanced (b) can be fully balanced
   (c) can be partially balanced (d) none of these
7. The primary unbalanced force is maximum when the angle of crank with the line of stroke is _____.
   (a) 45° (b) 90°
   (c) 135° (d) 180°
8. Which of the following statements are correct?
   (a) If a rotor is statically balanced, it is also dynamically balanced.
   (b) If a rotor is dynamically balanced, it is also statically balanced.
   (c) If a rotor is dynamically balanced, it may or may not be statically balanced.
   (d) None of above.
9. _______ can completely balance a system of several masses revolving in different planes on a shaft.
   (a) Two masses in any two planes
   (b) Two equal masses in any two planes
   (c) Two masses in any of the two planes of revolving masses only
   (d) A single mass in any plane
10. An eccentric mass rotating at 2000 rpm will create ______times more unbalanced force than half of the same mass rotating at 200 rpm.
    (a) 20 (b) 50
    (c) 200 (d) 2000
11. Primary unbalance force due to inertia of reciprocating parts of mass m at a radius r moving with an angular velocity ω is
    (a) $mr\omega^2 \cos\theta$ (b) $mr\omega^2 \sin\theta$
    (c) $mr\omega^2 \cos\left(\frac{2\theta}{n}\right)$ (d) $mr\omega^2 \sin\left(\frac{2\theta}{n}\right)$
12. A _____ cylinder inline engine working on four-stroke cycle is completely balanced inherently.
    (a) 2 (b) 3
    (c) 4 (d) 6
13. A four-cylinder four-stroke inline engine is not balanced for
    (a) primary forces (b) primary couples
    (c) secondary forces (d) secondary couples
14. What should be the angle between the axes of a 2-cylinder V-engine to balance the primary forces completely?
    (a) 30° (b) 45°
    (c) 60° (d) 90°
15. A rotating disc of 1-m diameter has two eccentric masses of 0.5 kg each at radii of 50 mm and 60 mm at angular positions of 0° and 150°, respectively. A balancing mass of 0.1 kg is to be used to balance the rotor. What is the radial position of the balancing mass?
    (a) 50 mm (b) 120 mm
    (c) 150 mm (d) 280 mm
16. In a four-stroke engine, the secondary imbalance has a frequency equal to ____ times engine speed.
    (a) 2 (b) 4
    (c) 8 (d) 16

17. An instantaneous configuration of a four-bar mechanism, whose plane is horizontal, is shown in Fig. 14.52. At this instant, the angular velocity and angular acceleration of link O_2A are $\omega = 8$ rad/s and $\alpha = 0$, respectively, and the driving torque (τ) is zero. The link O_2A is balanced so that its centre of mass falls at O_2. At the same instant, if the component of the force at joint A along AB is 30 N, then the magnitude of the joint reaction at O_2 is

(a) zero (b) 30 N
(c) 78 N (d) cannot be determined

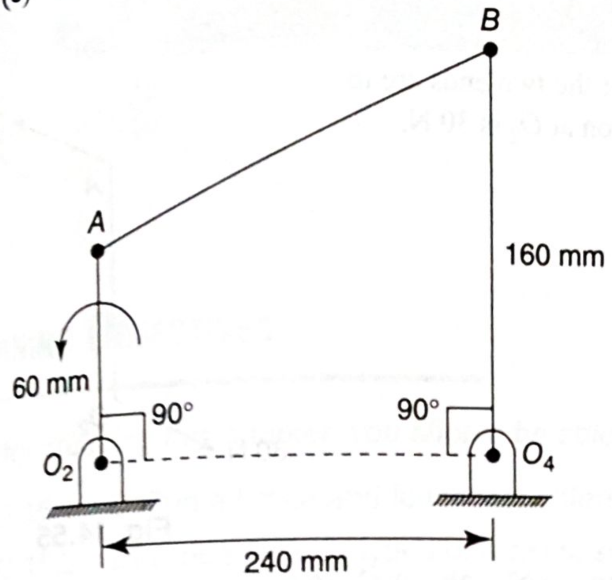

Fig. 14.52

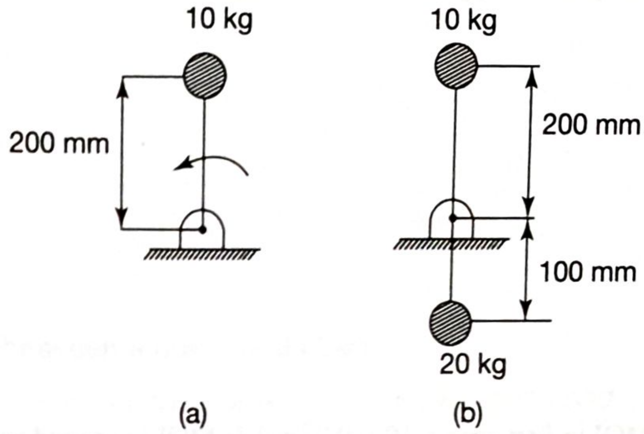

Fig. 14.53

18. A rigid body shown in the Fig. 14.53 has a mass of 10 kg. It rotates with a uniform angular velocity ω. A balancing mass of 20 kg is attached as shown in the figure. The percentage increase in mass moment of inertia as a result of this addition is

(a) 25% (b) 50%
(c) 100% (d) 200%

19. Two masses m are attached to opposite sides of a rigid rotating shaft in the vertical plane. Another pair of equal masses m_1 is attached to the opposite sides of the shaft in the vertical plane as shown in Fig. 14.54. Consider $m = 1$ kg, $e = 50$ mm, $e_1 = 20$ mm, $b = 0.3$ m, $a = 2$ m and $a_1 = 2.5$ m. For the system to be dynamically balanced, m_1 should be ___ kg.

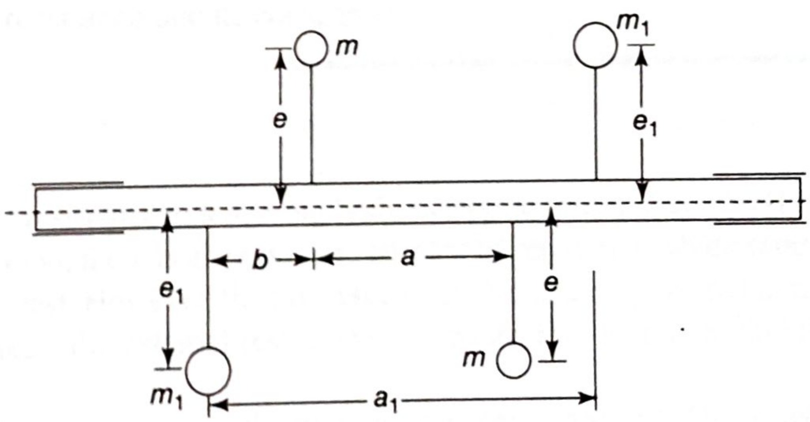

Fig. 14.54

Answers to Multiple-Choice Questions

1. (a)	2. (c)	3. (a)	4. (a)	5. (b)	6. (c)	7. (d)	8. (b)
9. (a)	10. (c)	11. (a)	12. (d)	13. (c)	14. (d)	15. (c)	16. (a)
17. (b)	18. (b)	19. 2					

Hints to Multiple-Choice Questions

15. Use Eq. (14.3); $m_c r_c = \sqrt{\begin{array}{l}\left[(0.5 \times 50)\cos 0° + (0.5 \times 60)\cos 150°\right]^2 \\ +\left[(0.5 \times 50)\sin 0° + (0.5 \times 60)\sin 150°\right]^2\end{array}} = 15$

$r_c = 15/0.1 = 150$ mm

17. In free-body diagram of link O_2A (Fig. 14.55), the forces at the two ends are to be equal and opposite. So, the magnitude of the joint reaction at O_2 is 30 N.

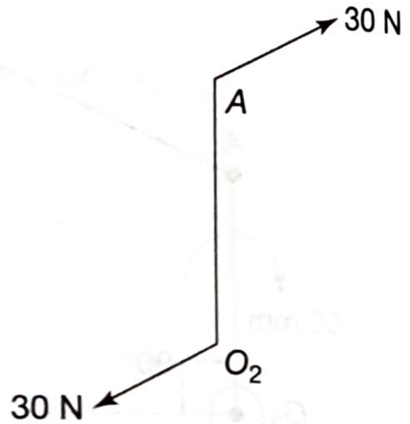

Fig. 14.55

18. MOI in first case $= 10 \times 0.2^2 = 0.4$; MOI in second case $= 10 \times 0.2^2 + 20 \times 0.1^2 = 0.6$
Increase $= (0.6 - 0.4)/0.4 = 0.5$ or 50%

19. Couple due to m = couple due to m_1 or $m \times e \times a = m_1 \times e_1 \times a_1$
or $1 \times 0.05 \times 2 = m_1 \times 0.02 \times 2.5$ or $m_1 = 2$ kg

Multiple-Choice Questions

1. On applying brakes to a moving vehicle, the kinetic energy is converted into
   (a) potential energy (b) mechanical energy
   (c) heat energy (d) none of these
2. Which of the following brakes is commonly used in motor cars?
   (a) Band brake (b) Shoe brake
   (c) Band and block brake (d) Internal expanding shoe brake
3. Brakes commonly used in trains are ______ brakes.
   (a) band (b) shoe
   (c) band and block (d) internal expanding shoe
4. Double block brake is a type of
   (a) shoe brake (b) band brake
   (c) internal expanding shoe brake (d) none of these
5. In a single shoe brake, uniform normal pressure between block and drum can safely be considered when angle of contact is less than
   (a) 40° (b) 60°
   (c) 80° (d) 100°
6. In which type of brake, wooden blocks are kept inside a flexible steel band?
   (a) Band brake (b) Block brake
   (c) Band and block brake (d) Internal expanding shoe brake
7. In a self-locking brake, the force required to apply the brake is
   (a) minimum (b) zero
   (c) maximum (d) none of these
8. When the frictional force helps the applied force in applying the brake, the brake is
   (a) self-locking (b) automatic
   (c) self-energising (d) none of these
9. In an internal expanding shoe brake, more than 50% of the total braking torque is supplied by
   (a) leading shoe (b) trailing shoe
   (c) any of the two (d) none of these
10. The ratio of tensions on the tight and slack sides in a band and block brake is given by

   (a) $\dfrac{T_n}{T_o} = \left(\dfrac{1-\mu\tan\theta}{1+\mu\tan\theta}\right)^n$ (b) $\dfrac{T_n}{T_o} = \left(\dfrac{1+\mu\tan\theta}{1-\mu\tan\theta}\right)^n$

   (c) $\dfrac{T_n}{T_o} = \left(\dfrac{1+\mu\tan\theta}{1-\mu\tan\theta}\right)^{1/n}$ (d) $\dfrac{T_n}{T_o} = \left(\dfrac{1-\mu\tan\theta}{1-\mu\tan\theta}\right)^{1/n}$

11. Tractive resistance during the propulsion of a wheeled vehicle depends on
    (a) road resistance
    (b) aerodynamic resistance
    (c) gradient resistance
    (d) all the above
12. Which lubricant is used in a rope brake dynamometer?
    (a) Oil
    (b) Water
    (c) Grease
    (d) No lubricant
13. A dynamometer is used to measure
    (a) force
    (b) torque
    (c) power
    (d) all of these
14. Which of the following is an absorption type of dynamometer?
    (a) Prony brake
    (b) epicyclic-train
    (c) Tatham
    (d) torsion
15. Which of the following is not transmission type of dynamometer?
    (a) Tatham
    (b) Epicyclic-train
    (c) Prony brake
    (d) Torsion

Answers to Multiple-Choice Questions

1. (c)	2. (d)	3. (b)	4. (a)	5. (a)	6. (c)	7. (b)	8. (c)
9. (a)	10. (b)	11. (d)	12. (b)	13. (d)	14. (a)	15. (c)	

Multiple-Choice Questions

1. Height of a governor is the distance measured from
   (a) centre of ball mass to point of intersection of lower arms
   (b) centre of ball mass to point of intersection of upper arms
   (c) point of intersection of upper arms to point of intersection of lower arms
   (d) none of above
2. The height of a Watt governor is
   (a) g/ω^3 (b) ω^2/g
   (c) $g\omega^2$ (d) g/ω^2
3. A Watt governor can work satisfactorily only at
   (a) low speeds (b) medium speeds
   (b) high speeds (d) at all speeds
4. The ratio of height of a Porter governor to that of a Watt governor when the lengths of the links and the arms are the same is
   (a) $\dfrac{M+m}{M}$ (b) $\dfrac{M+m}{m}$
   (c) $\dfrac{M}{M+m}$ (d) $\dfrac{m}{M+m}$
5. Which one of the following is a dead weight type of governor
   (a) Porter (b) Hartnell
   (c) Wilson Hartnell (d) Hartung
6. Which one of the following is a pendulum type of governor
   (a) Watt (b) Porter
   (c) Proell (d) Hartnell
7. Which of the following is a spring-loaded governor
   (a) Watt (b) Porter
   (c) Hartnell (d) Proell
8. Which of the following is not a spring-loaded governor
   (a) Hartnell (b) Hartung
   (c) Wilson Hartnell (d) None of these
9. Which of the following governors is not suitable for high speeds
   (a) Porter (b) Hartnell
   (c) Wilson Hartnell (d) Watt
10. A Hartnell governor is a/an _____ governor
    (a) dead weight (b) pendulum type
    (c) inertia (d) spring-loaded
11. The frictional resistance at the sleeve _____ the sensitivity of governor.
    (a) does not affect (b) increases
    (c) decreases (d) may increase or decrease
12. The force acting on the sleeve for a governor running at a constant speed is
    (a) zero (b) minimum
    (c) maximum (d) depends upon the speed
13. The force resisting the outward movement of balls is known as _____ of the governor.
    (a) effort (b) centripetal force
    (c) controlling force (d) inertia force

14. How many leaf springs are there in a Pickering governor
    (a) One
    (b) Two
    (c) Three
    (d) Four
15. In a Wilson Hartnell governor the balls are connected by
    (a) one spring
    (b) two springs in series
    (c) two parallel springs
    (d) four springs
16. Effort of a governor is the force exerted by the governor on the
    (a) balls
    (b) sleeve
    (c) upper links
    (d) lower links
17. The condition of isochronism can be realised in a ______ governor.
    (a) Watt
    (b) Porter
    (c) Proell
    (d) Harnell
18. The sensitivity of an isochronous governor is
    (a) zero
    (b) one
    (c) four
    (d) infinity
19. For a fractional change of speed, if the movement of the sleeve is large, then the governor is said to be
    (a) isochronous
    (b) hunting
    (c) sensitive
    (d) stable
20. Friction at the sleeve of a centrifugal governor makes it
    (a) more stable
    (b) unstable
    (c) more sensitive
    (d) insensitive over a small range of speed
21. In a governor if the equilibrium speed is constant for all radii of rotation of balls, the governor is said to be
    (a) stable
    (b) unstable
    (c) inertia
    (d) isochronous
22. The governor is said to be _____ when the speed of the engine fluctuates continuously above and below the mean speed
    (a) isochronous
    (b) hunting
    (c) insensitive
    (d) stable
23. For a governor to be stable, the slope of the controlling force curve must be ______ than/to that of the speed curve.
    (a) equal
    (b) greater
    (c) less
    (d)
24. If the controlling force of a spring-controlled governor is expressed as $a.r + b$, where r is the radius of rotation and a and b are constants, it is a/an _____ governor.
    (a) isochronous
    (b) stable
    (c) unstable
    (d) inertia
25. A spring control governor is a stable governor if the controlling force is related to the radius by the relation
    (a) $F = a.r + b$
    (b) $F = ar$
    (c) $F = a/r + b$
    (d) $F = a.r - b$
26. A governor is stable if the radius of rotation of the balls
    (a) decreases as the equilibrium speed increases
    (b) increases as the equilibrium speed decreases
    (c) increases as the equilibrium speed increases
    (d) does not change if the equilibrium speed changes
27. Sensitiveness of a governor is the ratio of
    (a) range of speed to the mean speed
    (b) range of speed to the minimum speed
    (c) range of speed to the maximum speed
    (d) Maximum speed to the minimum speed
28. The problem of hunting in a centrifugal governor increases if it becomes
    (a) less stable
    (b) highly stable
    (c) less sensitive
    (d) highly sensitive

29. Which of the following statement is correct:
   (a) Flywheel reduces speed fluctuations during a cycle for a constant load, but flywheel does not control the mean speed of the engine if the load changes.
   (b) Flywheel does not reduce speed fluctuation during a cycle for a constant load, but flywheel does not 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 control the mean speed of the engine if the load changes.

Answers to Multiple-Choice Questions

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

Multiple-Choice Questions

1. The magnitude of the gyroscopic couple applied to a disc of moment of inertia I, spinning with an angular velocity ω and having an angular velocity of precession ω_p is

   (a) $I^2\omega\omega_p$ (b) $I\omega^2\omega_p$

   (c) $I\omega\,\omega_p^2$ (d) $I\omega\omega_p$

2. The gyroscopic acceleration is given by

   (a) $\dfrac{\delta\omega'}{\delta t}$ (b) $\omega\dfrac{\delta\theta}{\delta t}$

   (c) $r\dfrac{\delta\theta}{\delta t}$ (d) $r\dfrac{\delta\omega}{\delta t}$

3. If the air screw of an aeroplane rotates clockwise when viewed from the rear and the aeroplane takes a right turn, the grosocopic effect will

   (a) tend to raise the tail and depress the nose (b) tend to raise the nose and depress the tail

   (c) tilt the aeroplane about spin axis (d) none of the above

4. The axis of spin, the axis of precession and the axis of gyroscopic torque are in

   (a) two parallel planes (b) two perpendicular planes

   (c) three perpendicular planes (d) three parallel planes

5. The effect of gyroscopic torque on the naval ship when it is rolling and the rotor is spinning about the longitudinal axis is
   (a) to raise the bow and lower the stern
   (b) to lower the bow and raise the stern
   (c) to turn the ship to one side
   (d) none of the above
6. A flat road has a curve segment with a radius of 100 m. while negotiating this curve, a vehicle slipped on its tyres as well as tried to rollover at a particular speed. Calculate this speed assuming a friction coefficient of 0.5. Also calculate the height of CG of the vehicle above ground if the tread (distance between the tyres at the front or rear) is 1.2 m.
7. A car is moving on a curved horizontal road of radius 100 m with a speed of 20 m/s. The rotating masses of the engine have an angular speed of 100 rad/s in clockwise direction when viewed from the front of the car. The combined moment of inertia of the rotating masses is 10 kg.m^2. The magnitude of the gyroscopic moment is ______ N.m.
8. An aeroplane makes a half circle towards left. The engine runs clockwise when viewed from the rear. Gyroscopic effect on the aeroplane causes the nose to (lift/dip).

Answers to Multiple-Choice Questions

1. (d)	2. (b)	3. (a)	4. (c)	5. (d)	6. 22.1, 1.2
7. 200	8. Lift				

Hints to Multiple-Choice Questions

6. As data is not sufficient to calculate the gyroscopic couple, it is ignored.
   At the point of slip, the frictional force must be equal to centrifugal force,
   Frictional force = $\mu.mg$

   $$\text{Centrifugal force} = mR\omega^2 = mR\left(\frac{v}{R}\right)^2 = \frac{mv^2}{R}$$

   $$\text{or } 0.5mg = \frac{mv^2}{100} \text{ or } v^2 = 490.5 \text{ or } v = 22.1 \text{ m/s}$$

   Also the couple due to weight must be equal to the overturning couple due to centrifugal force

   $$\text{i.e., } mg \times 0.6 = \frac{mv^2}{R} \times h \text{ or } 9.81 \times 0.6 = \frac{490.5}{100} \times h \text{ or } h = 1.2 \text{ m}$$

7. $$\text{Gyroscopic moment} = I\omega\omega_p = 10 \times 100 \times \frac{20}{100} = 200 \text{ N.m}$$

8. Refer Example 17.3; the nose is lifted.

Multiple-Choice Questions

1. A reduction in amplitude of successive oscillations indicate______ vibrations.
   (a) free (b) forced
   (c) damped (d) natural
2. The particles of a body moves____ its axis in longitudinal vibrations.
   (a) in a circle about (b) parallel to
   (c) perpendicular to (d) away from
3. The particles of a body moves____ its axis in torsional vibrations.
   (a) in a circle about (b) parallel to
   (c) perpendicular to (d) away from
4. In a spring mass system, if the mass is halved and the spring stiffness is doubled, the natural frequency is
   (a) halved (b) doubled
   (c) unchanged (d) quadrupled
5. In free vibrations, the velocity vector leads the displacement vector by
   (a) π (b) $\pi/2$
   (c) $\pi/3$ (d) $2\pi/3$
6. In free vibrations, the acceleration vector leads the displacement vector by
   (a) π (b) $\pi/2$
   (c) $\pi/3$ (d) $2\pi/3$
7. The amplitude ratio of two successive oscillations of a damped vibratory system is
   (a) more than one (b) less than one
   (c) equal to one (d) variable
8. In a spring mass system, if the mass is doubled and the spring stiffness is halved, the natural frequency is
   (a) halved (b) doubled
   (c) unchanged (d) quadrupled
9. The critical damping coefficient of a system with a mass of 1 kg attached to the end of a spring with a stiffness 0.9 N/mm is
   (a) 30 N/m/s (b) 60 N/m/s
   (c) 120 N/m/s (d) 600 N/m/s
10. An over-damped system
    (a) does not vibrate at all
    (b) vibrates with frequency more than natural frequency of system
    (c) vibrates with frequency less than natural frequency of system
    (d) vibrates with frequency equal than natural frequency of system
11. The ratio of the amplitude of the steady state response of forced vibrations to the static deflection under the action of static force is known as
    (a) damping ratio (b) damping factor
    (c) transmissibility (d) magnification factor
12. The frequency of damped vibrations is always ____ the natural frequency.
    (a) equal to (b) more than
    (c) less than (d) double
13. With usual notation, for a single degree of freedom system, the equation, $m\ddot{x} + 36\pi^2 x = 0$ represents a natural frequency of
    (a) 3 Hz (b) 3π Hz
    (c) 6 Hz (d) 6π Hz

14. With usual notation, for a single degree of freedom system, the equation of motion is $4\ddot{x} + 9\dot{x} + 16x = 0$. The damping ratio of the system is
(a) 9/8
(b) 9/16
(c) 9/32
(d) 9/64

15. With usual notation, for a single degree of freedom system, the equation, $m\ddot{x} + c\dot{x} + sx = F_0 \sin \omega t$ represents
(a) free vibration with damping
(b) free vibration without damping
(c) forced vibration with damping
(d) forced vibration without damping

16. A spring of stiffness s is displaced from a position x_1 to position x_2. The work done is
(a) $\frac{1}{2}s(x_1 - x_2)^2$
(b) $\frac{1}{2}s(x_1 + x_2)^2$
(c) $\frac{1}{2}sx_1^2 - \frac{1}{2}sx_1^2$
(d) $\frac{1}{2}sx_1^2 - \frac{1}{2}sx_1^2$

17. Resonance is a phenomenon in which the frequency of the exciting force is _____ to the natural frequency of the system.
(a) double
(b) half
(c) equal
(d) thrice

18. At resonance, the amplitude of vibration is
(a) very large
(b) small
(c) zero
(d) depends upon frequency

19. In damped force vibrations, the ratio of maximum displacement to the static deflection is known as
(a) damping factor
(b) critical damping factor
(c) magnification factor
(d) logarithmic decrement

20. Which type of damping is realised by a hydraulic dash-pot shock absorber?
(a) Coulomb
(b) Spring
(c) Structural
(d) Viscous

21. Transmissibility is the ratio of
(a) damping force to the spring force
(b) force transmitted to the foundation to the force applied to the machine
(c) force applied to the machine to the force transmitted to the foundation
(d) force transmitted to the foundation to the damping force

22. At a certain speed, revolving shafts tend to vibrate violently in transverse directions. The speed is known as
(a) whirling speed
(b) critical speed
(c) whipping speed
(d) all of these

23. The critical speed of rotating shaft with a mass at the centre is ____ the natural frequency of transverse vibration of the system.
(a) equal
(b) less than
(c) more than
(d) dependent upon

24. A torsional vibratory system having two rotors connected by a shaft has
(a) one node
(b) two nodes
(c) three nodes
(d) no node

25. A torsional vibratory system having three rotors connected by a shaft has
(a) one node
(b) two nodes
(c) three nodes
(d) no node

26. When shaking force is transmitted through the springs, damping is detrimental if the ratio of its frequency to the natural frequency is more than
    (a) 0.5 (b) 1
    (c) $\sqrt{2}$ (d) $\sqrt{3}$
27. If the mass of a critically damped single degree of freedom system is displaced from its equilibrium position and released, then it
    (a) oscillates with increased time period
    (b) oscillates with decreased time period
    (c) oscillates with constant amplitude
    (d) does not oscillate and returns to its equilibrium position
28. The critical speed of a rotating shaft depends on
    (a) mass and stiffness (b) mass and eccentricity
    (c) stiffness and eccentricity (d) mass, stiffness and eccentricity
29. In SHM, the positions of the velocity and acceleration vectors with respect to displacement vector are at
    (a) 0° and 90° (b) 90° and 180°
    (c) 90° and 0° (d) 180° and 90°
30. A compression coil spring is cut into two equal halves and each half is joined in parallel, the ratio of spring stiffness will be now ____ times of the original.
    (a) 1 (b) 2
    (c) 4 (d) 1/4
31. A motion is aperiodic when the value of the damping factor is
    (a) 0.25 (b) 0.5
    (c) 0.867 (d) 1 or above
32. In a multi-rotor system of torsional vibrations, if the number of rotors is n, the maximum number of nodes is
    (a) n (b) $n - 1$
    (c) $n - 2$ (d) $n + 1$
33. The rotor of a turbine is usually rotated at
    (a) the critical speed (b) a little above or below the critical speed
    (c) much below the critical speed (d) much above the critical speed
34. A viscous damping system with free vibrations is said to be critically damped if the damping factor is
    (a) less than 1 (b) more than one
    (c) one (d) zero
35. A point mass is executing simple harmonic motion with amplitude of 10 mm and frequency of 4 Hz. The maximum acceleration of the mass is ________ m/s².
36. A mass of 1 kg is attached to two identical springs each with stiffness s = 20 kN/m as shown in Fig. 18.56. Under frictionless condition, the natural frequency of the system in Hz is close to ____.
    (a) 32 (b) 23
    (c) 16 (d) 11

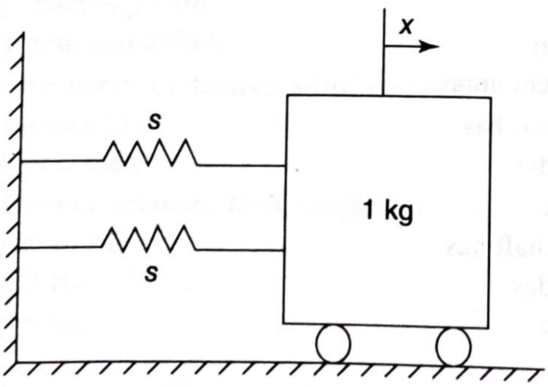

Fig. 18.56

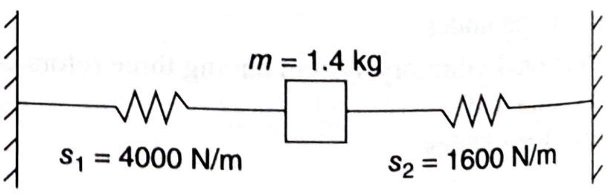

Fig. 18.57

37. The natural frequency of the spring mass system shown in Fig. 18.57 is closest to
(a) 8 Hz (b) 10 Hz
(c) 12 Hz (d) 14 Hz

38. The differential equation governing the vibrating system shown in Fig. 18.58 is

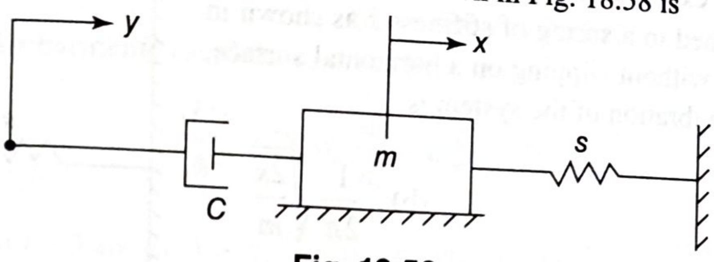

Fig. 18.58

(a) $m\ddot{x} + c\dot{x} + s(x - y) = 0$ (b) $m(\ddot{x} - \ddot{y}) + c(\dot{x} - \dot{y}) + sx = 0$
(c) $m\ddot{x} + c(\dot{x} - \dot{y}) + sx = 0$ (d) $m(\ddot{x} - \ddot{y}) + c(\dot{x} - \dot{y}) + s(x - y) = 0$

39. A weighing machine consists of a 2 kg pan resting on a spring. In this condition, the pan resting on the spring, the length of the spring is 200 mm. When a mass of 20 kg is placed on the pan, the length of the spring becomes 100 mm. For the spring, the undeformed length l_o and the spring constant s (stiffness) are
(a) $l_o = 220$ mm, $s = 1862$ N/m (b) $l_o = 210$ mm, $s = 1960$ N/m
(c) $l_o = 200$ mm, $s = 1960$ N/m (d) $l_o = 200$ mm, $s = 2156$ N/m

40. Consider the arrangement shown in Fig. 18.59 where J is the combined polar mass moment of inertia of the disc and the shafts. s_1, s_2, s_3 are the torsional stiffness's of the respective shafts. The natural frequency of torsional oscillation of the disc is given by

(a) $\sqrt{\dfrac{s_1 + s_2 + s_3}{J}}$ (b) $\sqrt{\dfrac{s_1s_2 + s_2s_3 + s_3s_1}{J(s_1 + s_1)}}$

(c) $\sqrt{\dfrac{s_1s_2s_3}{J(s_1s_2 + s_2s_3 + s_3s_1)}}$ (d) $\sqrt{\dfrac{s_1s_2 + s_2s_3 + s_3s_1}{J(s_2 + s_3)}}$

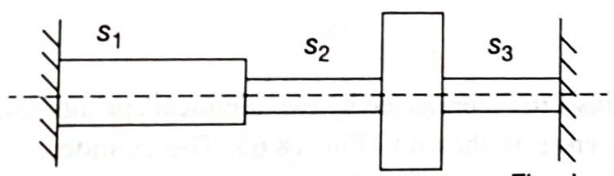

Fig. 18.59

41. The natural frequency of an undamped vibrating system is 100 rad/s. A damper with a damping factor of 0.8 is introduced into the system. The frequency of vibration of the damped system, in rad/s, is
(a) 60 (b) 75
(c) 80 (d) 100

42. A mass of 1 kg is suspended by means of 3 springs as shown in Fig. 18.60. The spring constants s_1, s_2, s_3 are respectively 1 kN/m, 3 kN/m and 2 kN/m. The natural frequency of the system is approximately
(a) 46.90 rad/s (b) 52.44 rad/s
(c) 60.55 rad/s (d) 77.46 rad/s

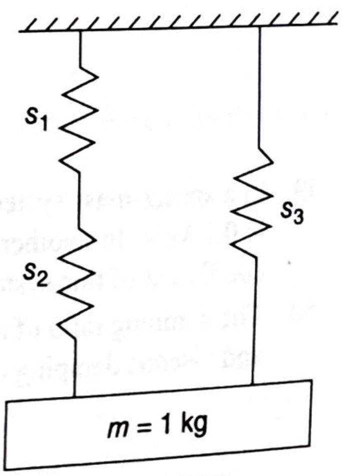

Fig. 18.60

43. The static deflection of a spring under gravity, when a mass of 1 kg is suspended from it, is 1 mm. Assume the acceleration due to gravity $g = 10$ m/s^2. The natural frequency of this spring-mass system is ______ rad/s.

44. A single degree of freedom system has a mass of 8 kg, stiffness 8 N/m and viscous damping ratio 0.02. The dynamic magnification factor at an excitation frequency of 1.5 rad/s is ______.

45. A disc of mass m is attached to a spring of stiffness s as shown in Fig. 18.61. The disc rolls without slipping on a horizontal surface. The natural frequency of vibration of the system is

(a) $\frac{1}{2\pi}\sqrt{\frac{s}{m}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{2s}{m}}$

(c) $\frac{1}{2\pi}\sqrt{\frac{2s}{3m}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{3s}{2m}}$

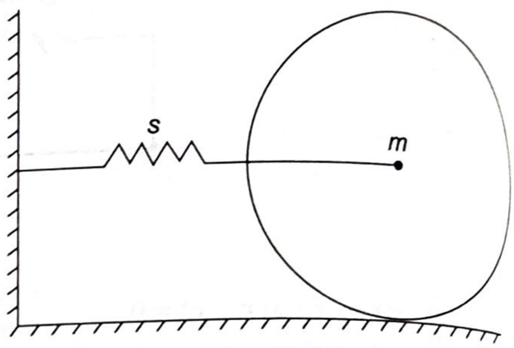

Fig. 18.61

46. A machine of 250 kg mass is supported on springs of total stiffness 100 kN/m. The machine has an unbalanced rotating force of 350 N at speed of 3600 rpm. Assuming a damping factor of 0.15, the value of transmissibility ratio is

(a) 0.0531 (b) 0.9922

(c) 0.0162 (d) 0.0028

47. A uniform stiff rod of length 300 mm and having a weight of 300 N is pivoted at one end and connected to a spring at the other end as shown in Fig. 18.62. For keeping the rod vertical in a stable position the minimum value of spring constant s needed is

(a) 300 N/m (b) 400 N/m

(c) 1000 N/m (d) 500 N/m

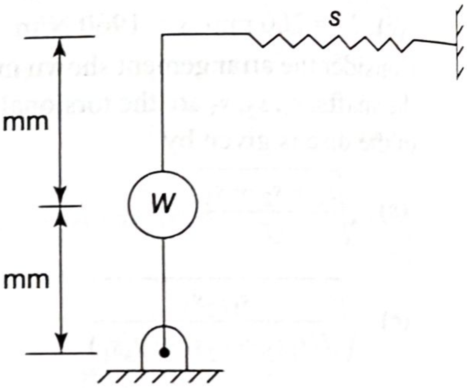

Fig. 18.62

48. A cylinder of mass 1 kg and radius 1 m is connected by two identical springs at a height of 0.5 m above the centre as shown in Fig. 18.63. The cylinder rolls without slipping. If the spring constant is 30 kN/m for each spring, find the natural frequency of the system for small oscillations.

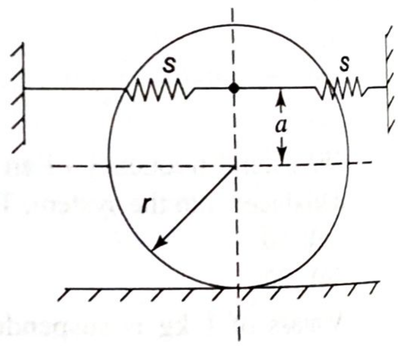

Fig. 18.63

49. In a spring-mass system, the mass is m and the spring constant is s. The critical damping coefficient of the system is 0.1 kg/s. In another spring-mass system, the mass is 2 kg and the spring constant is $8s$. The critical damping coefficient of this system is ______ kg/s.

50. The damping ratio of a single degree of freedom spring-mass-damper system with mass of 1 kg, stiffness 100 N/m and viscous damping coefficient of 25 N.s/m is ___.

51. A vehicle suspension system consists of a spring and a damper. The stiffness of the spring is 3.6 kN/m and the damping constant of the damper is 400 N./m/s. If the mass is 50 kg, then the damping factor and damped natural frequency respectively, are
(a) 0.471 and 1.19 Hz
(b) 0.471 and 7.48 Hz
(c) 0.666 and 1.35 Hz
(d) 0.666 and 8.50 Hz

52. The equation of motion of a harmonic oscillator is given by

$$\frac{d^2x}{dt^2} + 2\varsigma\omega_n \frac{dx}{dt} + \omega_n^2 x = 0,$$

and the initial conditions at $t = 0$ are $x(0) = X$, $\frac{dx}{dt}(0) = 0$. The amplitude of $x(t)$ after n complete cycles is
(a) $X(e)^{-2n\pi\left(\frac{\varsigma}{\sqrt{1-\varsigma^2}}\right)}$
(b) $X(e)^{2n\pi\left(\frac{\varsigma}{\sqrt{1-\varsigma^2}}\right)}$
(c) $X(e)^{-2n\pi\left(\frac{\sqrt{1-\varsigma^2}}{\varsigma}\right)}$
(d) X

53. In a spring-mass system, the mass is 0.1 kg and the stiffness of the spring is 1 kN/m. By introducing a damper, the frequency of oscillation is found to be 90% of the original value. What is the damping coefficient of the damper?
(a) 1.2 Ns/m
(b) 3.4 Ns/m
(c) 8.7 Ns/m
(d) 12.0 Ns/m

54. A cantilever beam of negligible weight is carrying a mass M at its free end, and is also resting on an elastic support of stiffness s_1 as shown in Fig. 18.64. If s_2 represents the bending stiffness of the beam, the natural frequency of the system is ______ rad/s.
(a) $\sqrt{\dfrac{s_1 s_2}{M(s_1 + s_2)}}$
(b) $\sqrt{\dfrac{2(s_1 + s_2)}{M}}$
(c) $\sqrt{\dfrac{s_1 + s_2}{M}}$
(d) $\sqrt{\dfrac{s_1 - s_2}{M}}$

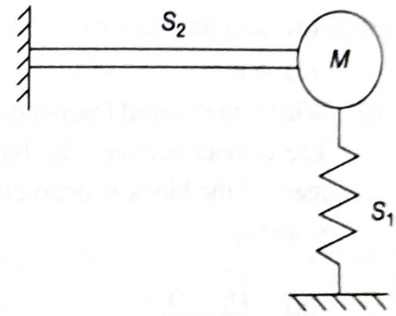

Fig. 18.64

55. In vibration isolation, which one of the following statements is NOT correct regarding Transmissibility (T)?
(a) T is nearly unity at small excitation frequencies
(b) T can always be reduced by using higher damping at any excitation frequency
(c) T is unity at the frequency ratio of $\sqrt{2}$.
(d) T is infinity at resonance for undamped systems

56. If two nodes are observed at a frequency of 1800 rpm during whirling of a simply supported long slender rotating shaft, the first critical speed of the shaft in rpm is
(a) 200
(b) 450
(c) 600
(d) 900

57. The natural frequency of a spring-mass system on earth is ω_n. The natural frequency of this system on the moon ($g_{moon} = g_{earth}/6$) is
(a) ω_n
(b) $0.408\ \omega_n$
(c) $0.204\ \omega_n$
(d) $0.167\ \omega_n$

58. For an under damped harmonic oscillator, resonance
(a) occurs when excitation frequency is greater than undamped natural frequency
(b) occurs when excitation frequency is less than undamped natural frequency
(c) occurs when excitation frequency is equal to undamped natural frequency
(d) never occurs

59. A vibratory system consists of a mass 12.5 kg, a spring of stiffness 1000 N/m, and a dashpot with damping coefficient of 15 Ns/m. The value of critical damping of the system is ______.N.s/m
(a) 0.223 (b) 17.88
(c) 71.4 (d) 223.6

60. A vibrating machine is isolated from the floor using springs. If the ratio of excitation frequency of vibration of machine to the natural frequency of the isolation system is equal to 0.5, the transmissibility of ratio of isolation is
(a) 1/2 (b) 3/4
(c) 4/3 (d) 2

61. As shown in Fig. 18.65, a mass of 100 kg is held between two springs. The natural frequency of vibration of the system, in Hz, is
(a) $\frac{1}{2\pi}$ (b) $\frac{5}{\pi}$
(c) $\frac{10}{\pi}$ (d) $\frac{20}{\pi}$

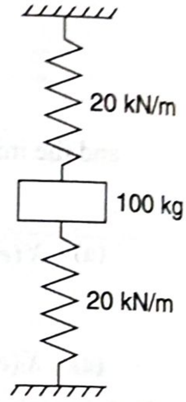

Fig. 18.65

62. The deflection of a spring with 20 active turns under a load of 1000 N is 10 mm. The spring is made into two pieces each of 10 active coils and placed in parallel under the same load. The deflection of the system is
(a) 20 mm (b) 10 mm
(c) 5 mm (d) 2.5 mm

63. What is the natural frequency of the spring mass system shown in Fig. 18.66? The contact between the block and the inclined plane is frictionless. The mass of the block is denoted by m and the spring constants are denoted by s_1 and s_2.
(a) $\sqrt{\frac{s_1 + s_2}{2m}}$ (b) $\sqrt{\frac{s_1 + s_2}{4m}}$
(c) $\sqrt{\frac{s_1 - s_2}{m}}$ (d) $\sqrt{\frac{s_1 + s_2}{m}}$

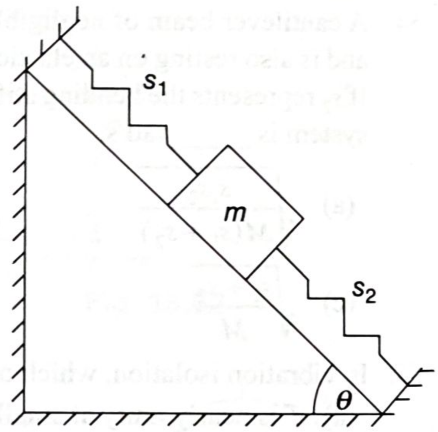

Fig. 18.66

64. An automotive engine weighing 240 kg is supported on four springs with linear characteristics. Each of the front two springs has a stiffness of 16 MN/m while the stiffness of each rear spring is 32 MN/m. The engine speed (in rpm), at which resonance is likely to occur, is
(a) 6040 (b) 3020
(c) 1424 (d) 955

65. The natural frequency of the system shown in Fig. 18.67 is
(a) $\sqrt{\frac{s}{2m}}$ (b) $\sqrt{\frac{s}{m}}$
(c) $\sqrt{\frac{2s}{m}}$ (d) $\sqrt{\frac{3s}{m}}$

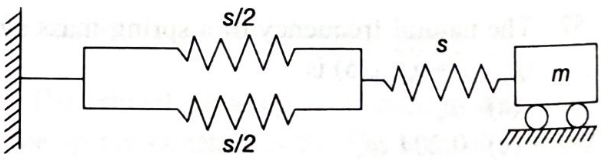

Fig. 18.67

66. The rotor shaft of a large electric motor supported between short bearings at both ends has a deflection of 1.8 mm in the middle of the rotor. Assuming the rotor to be perfectly balanced and supported at knife edges at both the ends, the likely critical speed of the shaft is ____ rpm.
(a) 350 (b) 705
(c) 2810 (d) 4430

67. A single degree of freedom spring-mass system shown in Fig. 18.68 is subjected to a harmonic force of constant amplitude. For an excitation frequency of $\sqrt{3s/m}$, the ratio of the amplitude of steady state response to the static deflection of the spring is ____.

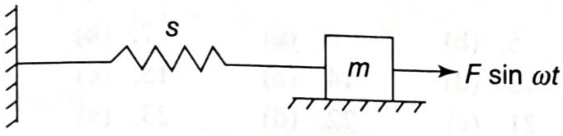

Fig. 18.68

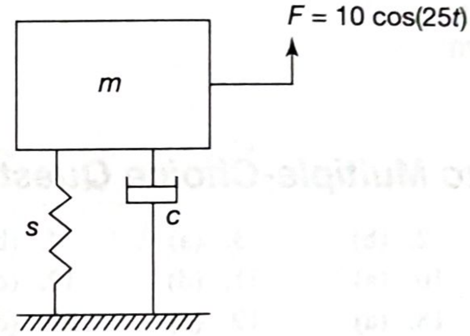

Fig. 18.69

68. A mass-spring-dashpot system with mass m = 10 kg, spring constant s = 6250 N/m is excited by a harmonic excitation of 10 cos (25t) N (Fig. 18.69). At the steady state, the vibration amplitude of the mass is 40 mm. The damping coefficient of the dashpot is _______ N/m/s.
69. In a single degree of freedom vibration system, the undamped natural frequency is _______ to/than the damped natural frequency. (greater/equal/less)
70. A precision instrument package (m = 1 kg) needs to be mounted on a surface vibrating at 60 Hz. It is desired that only 5% of the base surface vibration amplitude be transmitted to the instrument. Assuming that the isolation is designed with its natural frequency significantly lesser than 60 Hz, so that the effect of damping may be ignored. The stiffness of the required mounting pad is ________ N/m.
71. High damping reduces the transmissibility if the non-dimensional frequency ratio ω/ω_n is
    (a) less than $\sqrt{2}$ (b) greater than $\sqrt{2}$
    (c) less than $1/\sqrt{2}$ (d) greater than $1/\sqrt{2}$
72. A single degree of freedom spring mass system with viscous damping has a spring constant of 10 kN/m. The system is excited by a sinusoidal force of amplitude 100 N. If the damping factor (ratio) is 0.25, the amplitude of steady state oscillation at resonance is _____mm.
73. For lightly damped heavy rotor systems, resonance occurs when the forcing ω is equal to
    (a) $2\omega_{cr}$ (b) $\sqrt{2\omega_{cr}}$
    (c) ω_{cr} (d) $1/(2\omega_{cr})$
74. A solid disc with radius a is connected to a spring at a point d above the centre of the disc (Fig. 18.70). The other end of the spring is fixed to the vertical wall. The disc is free to roll without slipping on the ground. The mass of the disc is M and the spring constant is s. The polar moment of inertia for the disc about its centre is $J = Ma^2/2$. The natural frequency of this system in rad/s is given by

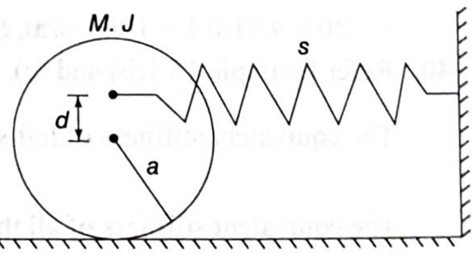

Fig. 18.70

    (a) $\sqrt{\dfrac{2s(a+d)^2}{3Ma^2}}$ (b) $\sqrt{\dfrac{2s}{3M}}$
    (c) $\sqrt{\dfrac{2s(a+d)^2}{Ma^2}}$ (d) $\sqrt{\dfrac{s(a+d)^2}{3Ma^2}}$
75. Consider a single degree-of-freedom system with viscous damping excited by a harmonic force. At resonance, the phase angle (in degree) of the displacement with respect to the exciting force is _______ degrees.
    (a) 0 (b) 45
    (c) 90 (d) 135

76. A single-degree. Freedom spring-mass system is subjected to a sinusoidal force of 10 N amplitude and frequency ω along the axis of the spring. The stiffness of the spring is 150 N/m, damping factor is 0.2 and the undamped natural frequency is 10ω. At steady state, the amplitude of vibration is approximately ______m.
    (a) 0.05 (b) 0.07
    (c) 0.70 (d) 0.90

Answers to Multiple-Choice Questions

1. (c)	2. (b)	3. (a)	4. (b)	5. (b)	6. (a)	7. (b)	8. (a)
9. (b)	10. (a)	11. (d)	12. (c)	13. (d)	14. (b)	15. (c)	16. (a)
17. (c)	18. (a)	19. (c)	20. (d)	21. (c)	22. (d)	23. (a)	24. (a)
25. (b)	26. (c)	27. (d)	28. (d)	29. (b)	30. (c)	31. (d)	32. (b)
33. (d)	34. (c)	35. 6.32.	36. (a)	37. (b)	38. (c)	39. (b)	40. (b)
41. (a)	42. (b)	43. 100	44. 0.799	45. (c)	46. (c)	47. (d)	48. 47.75
49. 0.4	50. 1.2	51. (a)	52. (a)	53. (c)	54. (c)	55. (b)	56. (a)
57. (a)	58. (c)	59. (d)	60. (c)	61. (c)	62. (d)	63. (d)	64. (a)
65. (a)	66. (b)	67. 0.5	68. 10	69. greater	70. 6768	71. (a)	72. 20
73. (c)	74. (a)	75. (c)	76. (b)				

Hints to Multiple-Choice Questions

35. Refer Section 18.6, The maximum acceleration

$$= X\omega_n^2 = X\left(2\pi f_n\right)^2 = 0.01\times\left(2\pi\times 4\right)^2 = 6.32 \text{ m/s}^2$$

36. Springs in parallel, combined stiffness $= s + s = 2s = 20 + 20 = 40$ kN/m;

$$f_n = \frac{1}{2\pi}\sqrt{\frac{40000}{1}} = 31.8 \text{ Hz}$$

37. Refer Example 18.1(c); $s = 4000 + 1600 = 5600$ N/m; $f_n = \dfrac{1}{2\pi}\sqrt{\dfrac{5600}{1.4}} = 10$ Hz
38. The displacement of piston of dashpot $= (x - y)$
39. On placing a mass of 20 kg, the length is decreased by 100 mm.

    $s = 20 \times 9.81/0.1 = 1960$ N/m, $l_o = 0.2 + 2 \times 9.81/1960 = 0.21$ m
40. Refer Example 18.1(b) and (c),

    The equivalent stiffness of left side two shafts $= \dfrac{s_1 s_2}{s_1 + s_2}$

    The equivalent stiffness of all the three shafts $= \dfrac{s_1 s_2}{s_1 + s_2} + s_3 = \dfrac{s_1 s_2 + s_2 s_3 + s_3 s_1}{J\left(s_1 + s_2\right)}$

$$\omega_n = \sqrt{\frac{s_1 s_2 + s_2 s_3 + s_3 s_1}{J\left(s_1 + s_2\right)}}$$

41. $\omega_d = \omega_n\sqrt{1-\zeta^2} = 100\times\sqrt{1-0.8^2} = 60$ rad/s
42. Similar to MCQ 40; $s_{eq} = \dfrac{s_1 s_2}{s_1 + s_2} + s_3 = \dfrac{1\times 3}{1+3} + 2 = 2.75$ kN/m

$$\omega_n = \sqrt{\frac{2750}{1}} = 52.44 \text{ rad/s}$$

43. $\omega_n = \sqrt{\dfrac{g}{\Delta}} = \sqrt{\dfrac{10}{1/0.001}} = 100$ rad/s

44. $\omega_n = \sqrt{\dfrac{8}{8}} = 1$,

$$\text{MF} = \frac{1}{\sqrt{\left[1-\left(\dfrac{\omega}{\omega_n}\right)^2\right]^2 + \left(2\zeta\dfrac{\omega}{\omega_n}\right)^2}} = \frac{1}{\sqrt{\left[1-\left(\dfrac{1.5}{1}\right)^2\right]^2 + \left(2\times 0.02\times\dfrac{1.5}{1}\right)^2}} = 0.799$$

45. Example 18.30

46. Use Eq. (18.42), $\omega_n = \sqrt{\dfrac{s}{m}} = \sqrt{\dfrac{100\,000}{250}} = 20$ rad/s, $\omega = \dfrac{2\pi\times 3600}{60} = 377$ rad/s; $\zeta = 0.15$

$$\text{Transmissibility} = \frac{\sqrt{1+\left(2\zeta\dfrac{\omega}{\omega_n}\right)^2}}{\sqrt{\left[1-\left(\dfrac{\omega}{\omega_n}\right)^2\right]^2 + \left(2\zeta\dfrac{\omega}{\omega_n}\right)^2}} = \frac{\sqrt{1+\left(2\times 0.15\times\dfrac{377}{20}\right)^2}}{\sqrt{\left[1-\left(\dfrac{377}{20}\right)^2\right]^2 + \left(2\times 0.15\times\dfrac{377}{20}\right)^2}}$$

$$= \frac{\sqrt{1+31.98}}{\sqrt{125544+31.98}} = 0.0162$$

47. Let the horizontal deflection of weight be x. Deflection of spring is double of that of weight (Fig. 18.71). Taking moments about the hinge, considering small oscillations of the rod,

$W.x = (s\times 2x)\times 0.3$ or $300x = s\times 2x\times 0.3$ *or* $s = 500$ N/m

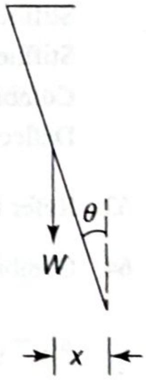

Fig. 18.71

48. Example 18.30; $f_n = \dfrac{1}{2\pi}\sqrt{\dfrac{4s(r+a)^2}{3mr^2}} = \dfrac{1}{2\pi}\sqrt{\dfrac{4\times 30000\times(1+0.5)^2}{3\times 1\times 1^2}} = 47.75$ Hz

49. For first mass, $0.1 = 2\sqrt{sm}$ [Eq.(18.25)]

For second mass, $c_c = 2\sqrt{(8s)(2m)} = 4\times 2\sqrt{sm} = 4\times 0.1 = 0.4$ kg/s

50. $\zeta = \dfrac{c}{c_c} = \dfrac{c}{2\sqrt{sm}} = \dfrac{25}{2\sqrt{100\times 1}} = 1.2$

51. $\zeta = \dfrac{c}{c_c} = \dfrac{c}{2\sqrt{sm}} = \dfrac{400}{2\sqrt{3600\times 50}} = 0.471$,

$\omega_n = \sqrt{\dfrac{3600}{50}} = 8.485.$ $\omega_d = \omega_n\sqrt{1-\zeta} = 8.485\times\sqrt{1-0.471^2}$

$= 7.48$ rad/s or $f_n = 7.48/2\pi = 1.19$ Hz

52. Refer Section 18.8, amplitude at the end of nth cycle

$$= Xe^{-\zeta\omega_n.n.T_d} = Xe^{-\zeta\omega_n.n.2\pi/\omega_d} = Xe^{-\zeta\omega_n.n.2\pi/\left(\omega_n\sqrt{1-\zeta^2}\right)} = Xe^{-\zeta.n.2\pi/\sqrt{1-\zeta^2}}$$

53. $\omega_d = \omega_n\sqrt{1-\zeta^2}$ or $0.9\omega_n = \omega_n\sqrt{1-\zeta^2}$ or $\zeta = 0.435$

$$c = 2\zeta\sqrt{sm} = 2\times 0.435\times\sqrt{1000\times 0.1} = 8.717$$

54. Similar to Example 18.1(c); Equivalent stiffness = $s_1 + s_2$

56. In case of two nodes, the frequency is nine times the fundamental frequency (refer Section 18.27). Thus, first critical speed = 1800/9 = 200

57. As $\omega_n = \sqrt{s/m}$, it does not depend upon value of g, thus it is same on the moon.

59. $c_c = 2\sqrt{sm} = 2\sqrt{1000\times 12.5} = 223.6$ N.s/m

60. Equation (18.44); As there is no damping, transmissibility $= \dfrac{1}{1-\left(\dfrac{\omega}{\omega_n}\right)^2} = \dfrac{1}{1-(0.5)^2} = \dfrac{4}{3}$

61. Example 18.1(c), $s = 20 + 20 = 40$ kN/m, $f_n = \dfrac{1}{2\pi}\sqrt{\dfrac{40\,000}{100}} = \dfrac{10}{\pi}$

62. If a spring is cut into two equal parts, double force is required to deflect the spring by the same amount. Thus stiffness is doubled.
Stiffness of first spring = 1000/10 = 100 N/mm
Stiffness of second spring = 200 N/mm
Combined stiffness of two springs = 200 + 200 = 400 N/mm
Deflection = 1000/400 = 2.5 mm

63. Refer Example 18.1(c), $s = s_1 + s_2$, so, $\omega_n = \sqrt{\dfrac{s_1+s_2}{m}}$

64. Combined stiffness = $16\times 2 + 32\times 2 = 96$ MN/m

$$\omega_n = \sqrt{\frac{s}{m}} = \sqrt{\frac{96\times 10^6}{240}} = 632.5 \text{ rad/s},\quad f_n = \frac{60\times 632.5}{2\pi} = 6040$$

65. For two springs in parallel, combined stiffness = $s/2 + s/2 = s$

Thus, total combined stiffness $= \dfrac{s\times s}{s+s} = s/2$, $\omega_n = \sqrt{\dfrac{s}{2m}}$

66. Equation (18.58); $\omega_n = \sqrt{\dfrac{g}{\Delta}} = \sqrt{\dfrac{9.81}{0.0018}} = 73.8$ rad/s or 705 rpm

67. Use Eq. (18.41), There is no damping, so,

$$MF = \pm\frac{1}{1-\left(\dfrac{\omega}{\omega_n}\right)^2} = \pm\frac{1}{1-\left(\dfrac{\sqrt{3s/m}}{\sqrt{s/m}}\right)^2} = 0.5 \text{ (Taking positive value\}}$$

68. Use Eq. (18.38), $A = \dfrac{F_o}{\sqrt{(s-m\omega^2)^2 + c\omega^2}}$

or $0.04 = \dfrac{10}{\sqrt{(6250-10\times 25^2)^2 + c\times 25^2}}$ or $c = 10$ N/m/s

70. Use Eq. (18.41), There is no damping, so, $MF = \pm\frac{1}{1-\left(\frac{\omega}{\omega_n}\right)^2}$ or $0.05 = \pm\frac{1}{1-\left(\frac{2\pi\times 60}{\omega_n}\right)^2}$

or $\left(\frac{2\pi\times 60}{\omega_n}\right)^2 = 21$ or $\omega_n = 82.27$ rad/s; Thus, $82.27 = \sqrt{\frac{s}{1}}$ or $s = 6768$ N/m

72. $$A = \frac{F_o/s}{\sqrt{\left[1-\left(\frac{\omega}{\omega_n}\right)^2\right]^2 + \left(2\zeta\frac{\omega}{\omega_n}\right)^2}} = \frac{100/10000}{\sqrt{\left[1-(1)^2\right]^2 + (2\times 0.25\times 1)^2}} = 0.02 \text{ m or } 20 \text{ mm}$$

73. At resonance, critical frequency is equal to the natural and forced frequencies
74. Similar to Example 18.30(b), Consider one spring instead of two.

76. $$A = \frac{\frac{F_o}{s}}{\sqrt{\left[1-\left(\frac{\omega}{10\omega_n}\right)^2\right]^2 + \left(2\times 0.2\times\frac{\omega}{10\omega_n}\right)^2}} = \frac{10/150}{\sqrt{\left[1-(0.1)^2\right]^2 + (2\times 0.2\times 0.1)^2}} = 0.066 \text{ near to } 0.07$$

Multiple-Choice Questions

1. A block diagram is a symbolic outline of a system in which various components or operations are represented by ______ in an ordered sequence.
   (a) circles
   (b) rectangles
   (c) triangles
   (d) parallelograms
2. In a first order system, the response is given by ______.
   (a) $y = x(e^{-\frac{t}{T}} - 1)$
   (b) $y = x - e^{-\frac{t}{T}}$
   (c) $y = x(1 - e^{-\frac{t}{T}})$
   (d) $y = x(1 - xe^{-\frac{t}{T}})$
3. The transfer function is the operational relationship of the output and the
   (a) command
   (b) response
   (c) input
   (d) error

Answers to Multiple-Choice Questions

1. (b) 2. (c) 3. (c)