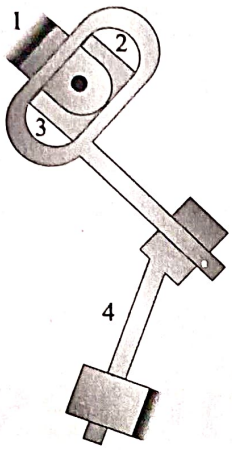
Chapter 1 Analysis of Planar Mechanism

One Mark Questions

01. For the planar mechanism shown in Fig. select the most appropriate choice for the motion of link 2 when link 4 is moved upwards. **(GATE–ME-99)**



(a) Link 2 rotates clockwise
(b) Link 2 rotates counter – clockwise
(c) Link 2 does not move
(d) Link 2 motion cannot be determined

02. The mechanism used in a shaping machine is **(GATE–ME-03)**
(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

03. The lengths of the links of a 4-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? **(GATE–ME-03)**
(a) link of length p (b) link of length q
(c) link of length r (d) link of length s

04. For a mechanism shown below, the mechanical advantage for the given configuration is **(GATE–ME-04)**

(a) 0 (b) 0.5
(c) 10 (d) ∞

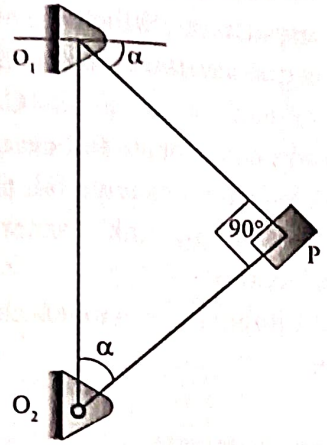
05. The number of degrees of freedom of a planar linkage with 8 links and 9 simple revolute joints is **(GATE–ME-05)**
(a)1 (b) 2 (c) 3 (d) 4

06. For a four bar linkage in Toggle position, the value of mechanical advantage is **(GATE–ME-06)**
(a) 0.0 (b) 0.5
(c) 1.0 (d) ∞

07. The number of inversions for a slider crank mechanism is **(GATE–ME-06)**
(a) 6 (b) 5 (c) 4 (d) 3

08. A planar mechanism has 8 links and 10 rotary joints. The number of degrees of freedom of the mechanism, using Grubler's criterion, is **(GATE–ME-08)**
(a) 0 (b) 1
(c) 2 (d) 3

09. A simple quick return mechanism is shown in the figure. The forward to return ratio of the quick return mechanism is 2 : 1. If the radius of the crank O_1P is 125 mm, then the distance 'd' (in mm) between the crank centre to lever pivot centre point should be



(GATE–ME-09)

(a) 144.3 (b) 216.5
(c) 240.0 (d) 250.0

10. Mobility of a statically indeterminate structure is **(GATE–ME-10)**

(a) ≤ -1 (b) 0
(c) 1 (d) ≥ 2

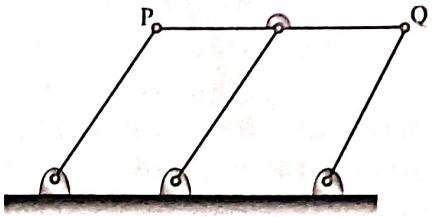
11. There are two points P and Q on a planar rigid body. The relative velocity between the two points **(GATE–ME-10)**

(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

12. Which of the following statements is INCORRECT? **(GATE–ME-10)**

(a) Grashof's rule states that for a planar crank-rocker four bar mechanism, the sum of the shortest and 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) Grubler's criterion assumes mobility of a planar mechanism to be one.

13. A double – parallelogram mechanism is shown in the figure. Note that PQ is a single link. The mobility of the mechanism is **(GATE–ME–11)**

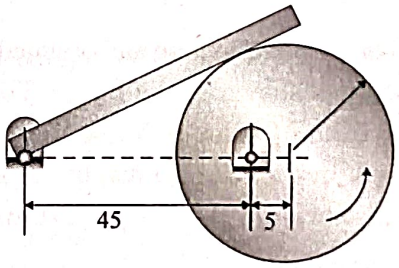


(a) – 1 (b) 0
(c) 1 (d) 2

14. A solid disc of radius r rolls without slipping on a horizontal floor with angular velocity ω and angular acceleration α. The magnitude of the acceleration of the point of contact on the disc is **(GATE–ME-12)**

(a) zero (b) rα
(c) $\sqrt{(r\alpha)^2+(r\omega)^2}$ (d) $r\omega^2$

15. In the mechanism given below, if the angular velocity of the eccentric circular disc is 1 rad/s, the angular velocity (rad/s) of the follower link for the instant shown in the figure is **(GATE–ME-12)**

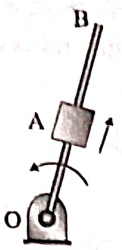


Note: All dimensions are in mm

(a) 0.05 (b) 0.1
(c) 5.0 (d) 10.0

16. A link OB is rotating with a constant angular velocity of 2 rad/s in counter clockwise direction and a block is sliding radially outward on it with an uniform velocity of 0.75 m/s with respect to the rod, as shown in the figure below. If OA = 1 m, the magnitude of the absolute acceleration of the block at location A in m/s² is

(GATE–ME-13)



(a) 3 (b) 4 (c) 5 (d) 6

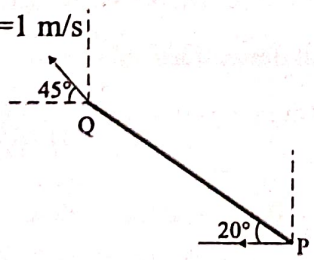
17. A planar closed kinematic chain is formed with rigid links PQ = 2.0 m, QR = 3.0 m, RS = 2.5 m and SP = 2.7 m with all revolute joints. The link to be fixed to obtain a double rocker (rocker-rocker) mechanism is (GATE–ME-13)

(a) PQ (b) QR (c) RS (d) SP

18. A circular object of radius r rolls without slipping on a horizontal level floor with the center having velocity V. The velocity at the point of contact between the object and the floor is (GATE–ME-14)

(a) zero
(b) V in the direction of motion
(c) V opposite to the direction of motion
(d) V vertically upward from the floor

19. A rigid link PQ is 2 m long and oriented at 20° to the horizontal as shown in the figure. 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 (GATE -ME-14)



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

20. A 4-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 link respectively. Which one of the following statements is true about the input and output links? (GATE -ME-14)

(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

21. For the given statements:

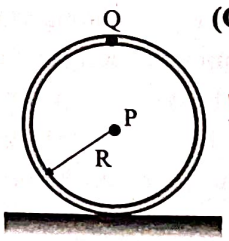
I. Mating spur gear teeth is an example of higher pair

II. A revolute joint is an example of lower pair.

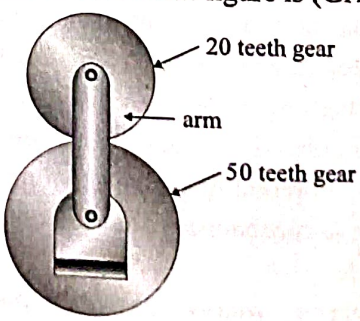
Indicate the correct answer. (GATE -ME-14)

(a) Both I and II are false (b) I is true and II is false
(c) I is false and II is true (d) Both I and II are true

22. A wheel of radius r rolls without slipping on a horizontal surface shown below. If The velocity of point P is 10 m/s in the horizontal direction, the magnitude of velocity of point Q (in m/s) is ____. (GATE –15 –Set 1)

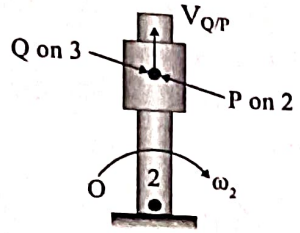


23. The number of degrees of freedom of the planetary gear train shown in the figure is (GATE–15 –Set 2)



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

24. In the figure, link 2 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



(GATE –15 –Set 3)

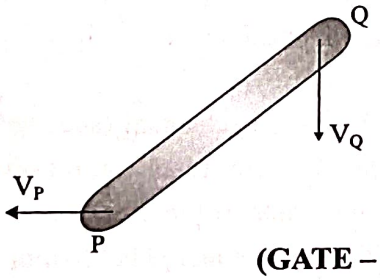
(a) $2\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction of ω_2.

(b) $\omega_2 V_{Q/P}$; direction of $V_{Q/P}$ rotated by 90° in the direction of 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 of ω_2.

25. A rigid link PQ is undergoing plane motion as shown in the figure (V_P and V_Q are non-zero). V_{QP} is the relative velocity of points Q with respect to point P.



(GATE – 16 – SET – 3)

Which one of the following is TRUE?

(a) V_{QP} has components along and perpendicular 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.

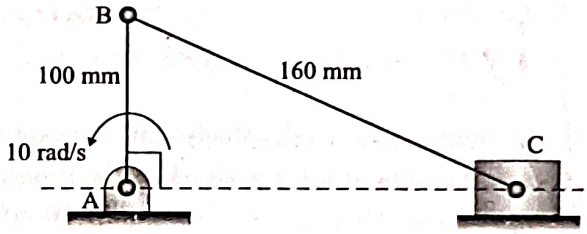
(d) V_{QP} has only one component perpendicular to PQ.

26. The number of degrees of freedom in a planar mechanism having n links and j simple hinge joints is **(GATE – 16 – SET – 3)**

(a) 3(n – 3) – 2j (b) 3(n – 1) – 2j

(c) 3n – 2j (d) 2j – 3n + 4

27. In a slider-crank mechanism, the lengths of the crank and the connecting rod are 100 mm and 160 mm, respectively. The crank is rotating with an angular velocity of 10 radian/s counter-clockwise. The magnitude of linear velocity (in m/s) of the piston at the instant corresponding to the configuration shown in the figure is_____



(GATE – 17 – SET – 2)

28. A four bar mechanism is made up of links of length 100, 200, 300 and 350 mm. If the 350 mm link is fixed, the number of links that can rotate fully is_____. **(GATE – 18 – SET – 1)**

29. For an Oldham coupling used between two shafts, which among the following statements are correct?

(I) Torsional load is transferred along shaft axis.

(II) A velocity ratio of 1:2 between shafts is obtained without using gears.

(III) Bending load is transferred transverse to shaft axis.

(IV) Rotation is transferred along shaft axis.

(GATE – 18 – SET – 1)

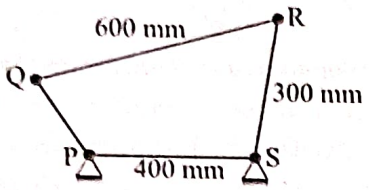
(a) I and III (b) I and IV

(c) II and III (d) II and IV

30. The link lengths of a planar four bar mechanism are AB = 100 mm, BC = 25 mm, CD = 75 mm and DA = 90 mm. For achieving the full rotation of both the input (crank) as well as the output (follower) links, the link that needs to be fixed is **(GATE – 19_PI)**

(a) AB (b) BC (c) CD (d) DA

31. A four bar mechanism is shown below.



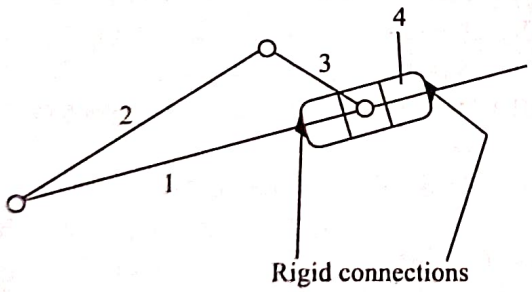
For the mechanism to be a crank-rocker mechanism, the length of the link PQ can be **(GATE–20–SET–1)**

(a) 200 mm (b) 350 mm
(c) 300 mm (d) 80 mm

32. The number of qualitatively distinct kinematic inversions possible for a Grashof chain with four revolute pairs is **(GATE–20–SET–2)**

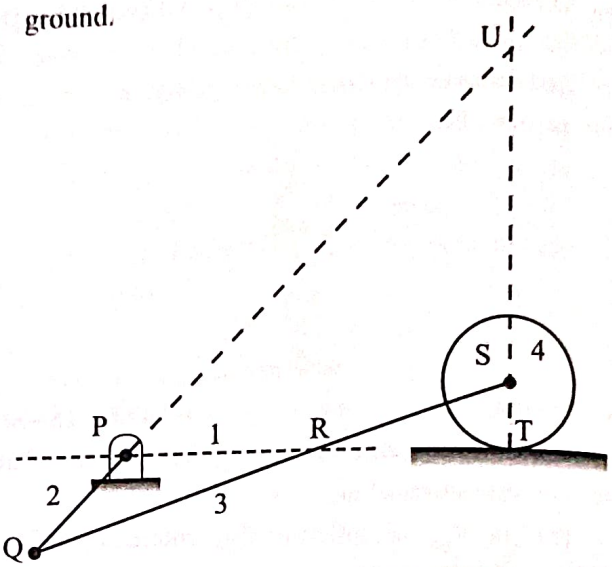
(a) 3 (b) 4 (c) 1 (d) 2

33. The figure shows a mechanism with 3 revolute pairs (between the links 1 and 2, 2 and 3, and 3 and 4) and a prismatic pair (between the links 1 and 4). Which one of the four links should be fixed to obtain the mechanism that forms the basis of the quick-return mechanism widely used in a shaper? **(GATE-PI-20)**



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

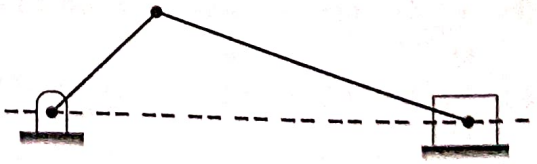
34. Consider the mechanism shown in the figure. There is rolling contact without slip between the disc and ground.



Select the correct statement about instantaneous centers in the mechanism. **(GATE–21_SET–2)**

(a) All points P, Q, R, S, T and U are instantaneous centers of mechanism
(b) Only points P, Q, R, S, and U are instantaneous centers of mechanism
(c) Only points P, Q, S and T are instantaneous centers of mechanism
(d) Only points P, Q, and S are instantaneous centers of mechanism

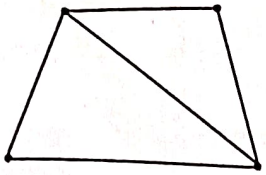
35. In a slider crank mechanism (schematic shown in the figure), the crank rotates at 60 revolutions per minute. The radius of the crank is 30 mm and the length of the connecting rod is 120 mm. The average speed (in mm/s) of the piston over one revolution of the crank is_____. [round off to nearest integer]



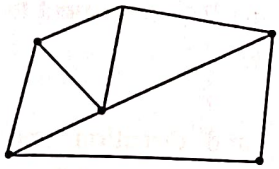
(GATE_PI-22)

36. The options show frames consisting of rigid bars connected by pin joints. Which one of the frames is non-rigid? **(GATE_ME-23)**

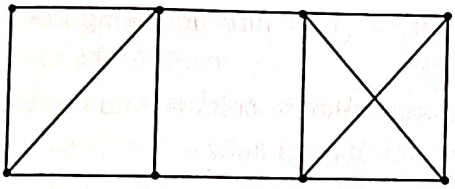
(a)



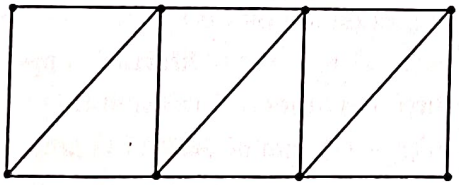
(b)



(c)



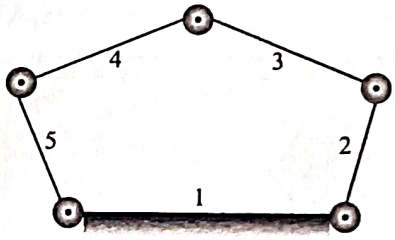
(d)



Two Marks Questions

01. Instantaneous center of a body rolling with sliding on a stationary curved surface lies **(GATE -ME-92)**
   (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 center of curvature of the stationary surface

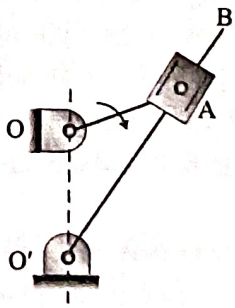
02. The number of degrees of freedom of a five link plane mechanism with five revolute pairs as shown in the figure is: **(GATE -ME-93)**



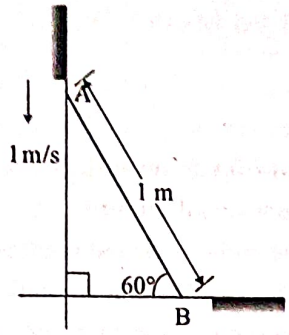
(a) 3 (b) 4 (c) 2 (d) 1

03. Fig. shows a quick return mechanism. The cranks OA rotates clockwise uniformly.
OA = 2 cm, OO^1 = 4 cm. The ratio of time for forward motion to that for return motion is **(GATE -ME-95)**

(a) 0.5
(b) 2.0
(c) $\sqrt{2}$
(d) 1



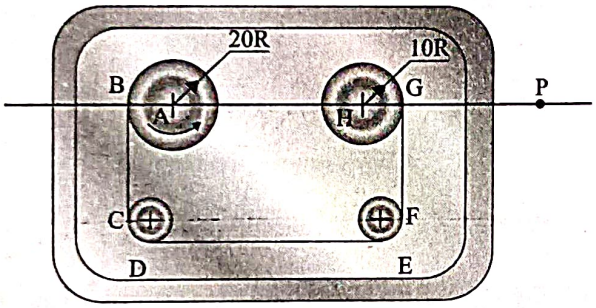
04. A rod of length 1m is sliding in a corner as shown in the figure. At an instant when the rod makes an angle of 60 degrees with the horizontal plane, the velocity of point A on the rod is 1 m/s. The angular velocity of the rod at this instant is **(GATE -ME-96)**



(a) 2 rad/s (b) 1.5 rad/s
(c) 0.5 rad/s (d) 0.75 rad/s

05. For the audio Cassette mechanism shown in Figure given below where is the instantaneous centre of rotation (point) of the two spools?

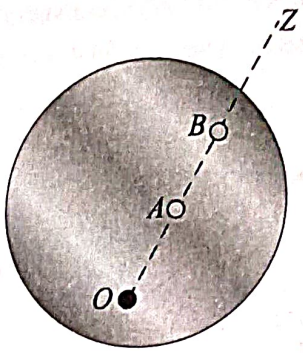
(GATE -ME-99)



(a) Point P lies to the left of both the spools but at infinity along the line joining A & H
(b) Point P lies in between the two spools on the line joining A & H, such that PH = 2AP
(c) Point P lies to the right of both the spools on the line joining A & H, such that AH = HP
(d) Point P lies at the intersection of the line joining B & C and the line joining G & F

Common Data for Q.Nos. 06 & 07

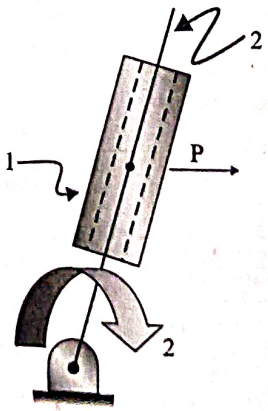
The circular disc shown in its plan view in the figure rotates in a plane parallel to the horizontal plane about the point O at a uniform angular velocity ω. Two other points A and B are located on the line OZ at distances r_A and r_B from O respectively. **(GATE -ME-03)**



06. 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

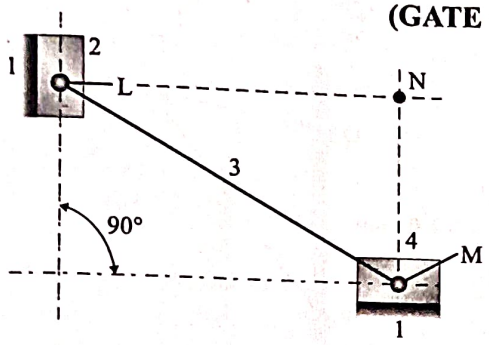
07. The acceleration of point B with respect to point A is a vector of magnitude
(a) 0
(b) $\omega(r_B^2 - r_A^2)$ and direction same as the direction of motion of point B
(c) $\omega^2(r_B - r_A)$ and direction opposite to the direction of motion of point B
(d) $\omega^2(r_B - r_A)$ and direction being from Z to O

08. In the figure shown, the relative velocity of link 1 with respect of link 2 is 12 m/sec. Link 2 rotates at a constant speed of 120 rpm. The magnitude of Coriolis component of acceleration of link 1 is **(GATE -ME-04)**



(a) 302 m/s²
(b) 604 m/s²
(c) 906 m/s²
(d) 1208 m/s²

09. The figure below shows a planar mechanism with single degree of freedom. The instant center I_{24} for the given configuration in located at a position. **(GATE -ME-04)**



(a) L (b) M (c) N (d) ∞

10. Match the following: **(GATE -ME-04)**

Type of Mechanism

P. Scott – Russel mechanism
Q. Geneva mechanism
R. Off-set slider- crank mechanism
S. Scotch Yoke mechanism

Motion achieved

1. Intermittent motion
2. Quick return motion
3. Simple harmonic motion
4. Straight line motion

Codes:	P	Q	R	S
(a)	2	3	1	4
(b)	3	2	4	1
(c)	4	1	2	3
(d)	4	3	1	2

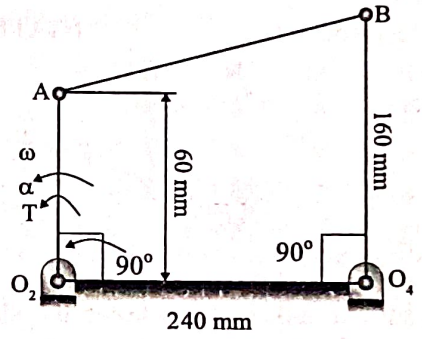
11. Match the following with respect to spatial mechanisms. **(GATE -ME-04)**

Type of Joint	Motion constrained
P. Revolute	1. Three
Q. Cylindrical	2. Five
R. Spherical	3. Four
	4. Two
	5. Zero

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

Common Data for Q.Nos. 12, 13 & 14.

An instantaneous configuration of a four-bar mechanism, whose plane is horizontal, is shown in the figure below. 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 (T) is zero. The link O_2A is balanced so that its centre of mass falls at O_2. **(GATE -ME-05)**



12. Which kind of 4-bar mechanism is O_2ABO_4?
(a) Double crank mechanism
(b) Crank-rocker mechanism
(c) Double rocker mechanism
(d) Parallelogram mechanism

13. At the instant considered, what is the magnitude of the angular velocity of O_4B?
(a) 1 rad/s (b) 3 rad/s
(c) 8 rad/s (d) 64/3 rad/s

14. At the same instant, if the component of the force in joint A along AB is 30N, then the magnitude of the joint reaction at O_2.
(a) is Zero
(b) is 30N
(c) is 78 N
(d) cannot be determined from the given data

15. Match the items in columns I and II

List – I

P. Higher kinematic pair
Q. Lower kinematic pair
R. Quick return mechanism
S. Mobility of a linkage

List – II

1. Grubler's equation
2. Line contact
3. Euler's equation
4. Planer
5. Shaper
6. Surface contact

(GATE -ME-06)

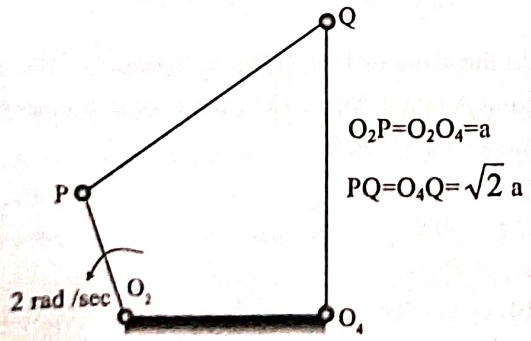
	P	Q	R	S
(a)	2	6	4	3
(b)	6	2	4	1
(c)	6	2	5	3
(d)	2	6	5	1

16. 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

(GATE -ME-06)

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

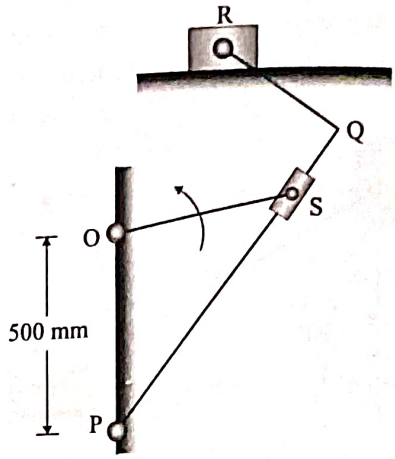
17. The input link O_2P of a four bar linkage is rotated at 2 rad/s counter clockwise direction as shown below. The angular velocity of the coupler PQ in rad/s, at an instant when $\angle O_4O_2P = 180°$, is **(GATE -ME-07)**



(a) 4 (b) $2\sqrt{2}$ (c) 1 (d) $\frac{1}{\sqrt{2}}$

Statement for Linked Answer Q.Nos. 18 & 19

A quick return mechanism is shown below. The crank OS is drive at 2 rev/s in counter clockwise direction. **(GATE -ME-07)**



18. If the quick return ratio is 1 : 2, then the length of the crank in mm is

(a) 250 (b) 250 $\sqrt{3}$ (c) 500 (d) 500 $\sqrt{3}$

19. The angular speed of PQ in rev/s when the block R attains maximum speed during forward stroke (stroke with slower speed) is

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

20. Match the approaches given below to perform stated kinematics/dynamics analysis of machine

(GATE -ME-09)

Analysis

P. Continuous relative rotation
Q. Velocity and acceleration
R. Mobility
S. Dynamic – static analysis

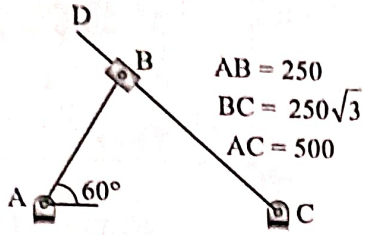
Approach

1. D' Alembert's principle
2. Grubler's criterion
3. Grashof's law
4. Kennedy's theorem

Codes:	P	Q	R	S
(a)	1	2	3	4
(b)	3	4	2	1
(c)	2	3	4	1
(d)	4	2	1	3

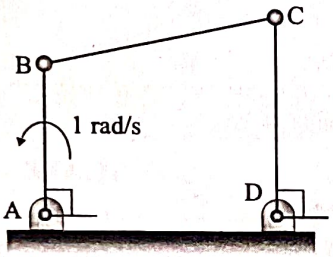
21. For the configuration shown, the angular velocity of link AB is 10 rad/s counterclockwise. The magnitude of the relative sliding velocity (in ms^{-1}) of slider B with respect to rigid link CD is

(GATE -ME-10)



(a)0 (b) 0.86 (c) 1.25 (d) 2.50

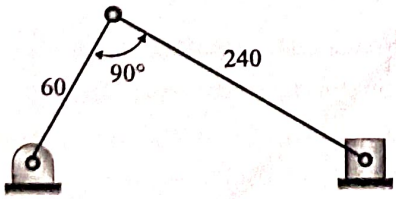
22. For the four – bar linkage shown in the figure, the angular velocity of link AB is 1 rad/s. The length of link CD is 1.5 times the length of link AB. In the configuration shown, the angular velocity of link CD in rad / s is **(GATE -ME-11)**



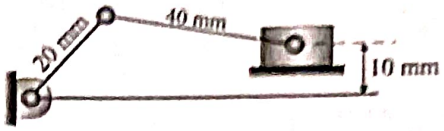
(a) 3 (b) 3/2 (c) 1 (d) 2/3

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

(GATE -ME-14)



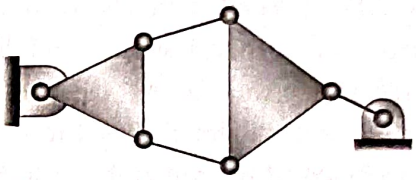
24. An offset slider – crank mechanism is shown in the figure at an instant. Conventionally, the Quick Return Ratio (QRR) is considered to be greater than one. The value of QRR is _____ **(GATE -ME-14)**



25. 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 (in m/s^2) is _____

(GATE –15 –Set 2)

26. The number of degree of freedom of the linkage shown in figure is

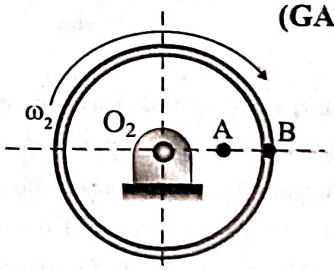


(GATE –15 –Set 3)

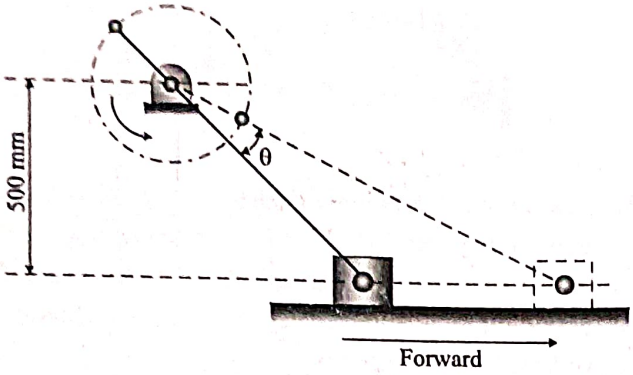
(a) –3 (b) 0 (c) 1 (d) 2

27. Figure 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 (in mm) is _____

(GATE –15 –Set 3)

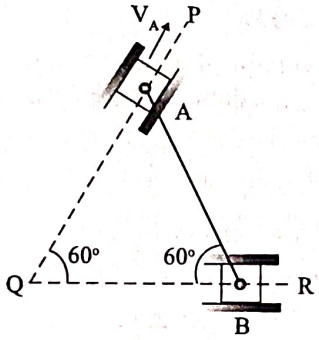


28. In an off-set slider crank mechanism, shown in figure, the crank is rotated at a constant speed of 150 rpm. The value of the angle θ shown in the figure is 20°. What is the ratio of forward to return stroke time? Can this mechanism be used in an application involving quick return ? **(GATE - PI –15)**



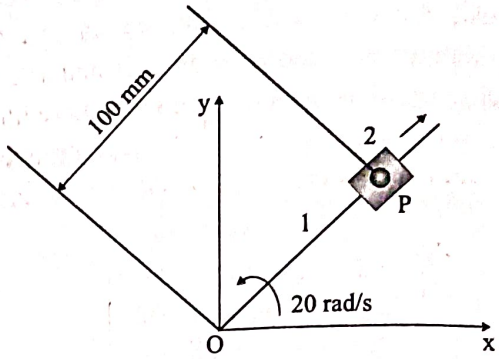
(a) 3.33, No (b) 0.73, yes
(c) 1.25, yes (d) 0.73, No

29. The rod AB, of length 1 m, shown in the figure is connected to two sliders at each end through pins. The sliders can slide along QP and QR. If the velocity V_A of the slider at A is 2 m/s, the velocity of the midpoint of the rod at this instant is _____ m/s. **(GATE – 16 – SET – 2)**



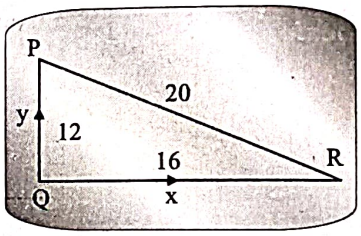
30. For an inline slider-crank mechanism, the lengths of the crank and connecting rod are 3 m and 4 m respectively. At the instant when the connecting rod is perpendicular to the crank, if the velocity of the slider is 1 m/s, the magnitude of angular velocity (upto 3 decimal points accuracy) of the crank is _____ radian/s. **(GATE – 17 – SET – 1)**

31. Block 2 slides outward on link 1 at a uniform velocity of 6m/s as shown in the figure. Link 1 is rotating at a constant angular velocity of 20 radian/s counterclockwise. The magnitude of the total acceleration (in m/s²) of point P of the block with respect to fixed point O is_____



(GATE – 17 – SET – 2)

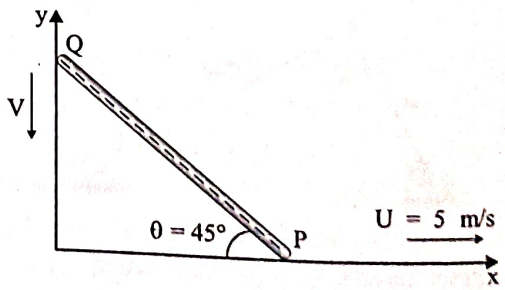
32. In a rigid body in plane motion, the point R is accelerating with respect to point P at $10\angle 180°$ m/s². If the instantaneous acceleration of point Q is zero, the acceleration (in m/s²) of point R is



(GATE – 18 – SET – 2)

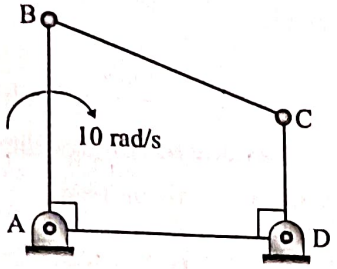
(a) $8 \angle 233°$ (b) $10 \angle 225°$
(c) $10 \angle 217°$ (d) $8 \angle 217°$

33. A rigid rod of length 1 m is resting at an angle $\theta = 45°$ as shown in the figure. The end P is dragged with a velocity of U = 5 m/s to the right. At the instant shown, the magnitude of the velocity V (in m/s) of point Q as it moves along the wall without losing constant is **(GATE – 18 – SET – 2)**



(a) 5 (b) 6 (c) 8 (d) 10

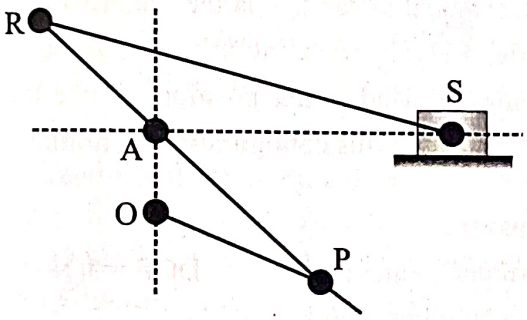
34. In a four bar planar mechanism shown in the figure, AB = 5 cm, AD = 4 cm and DC = 2 cm. In the configuration shown, both AB and DC are perpendicular to AD. The bar AB rotates with an angular velocity of 10 rad/s. The magnitude of angular velocity (in rad/s) of bar DC at this instant is



(GATE – 19 – SET – 1)

(a) 25 (b) 0 (c) 10 (d) 15

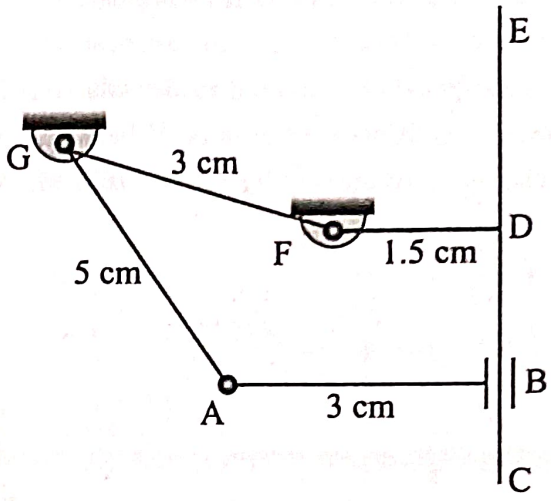
35. The Whitworth quick return mechanism is shown in the figure with link lengths as follows: OP = 300 mm, OA = 150 mm, AR = 160 mm, RS = 450 mm.



The quick return ratio for the mechanism is ____ (round off to one decimal place).

(GATE–21_SET–1)

36. A planar four-bar linkage mechanism with 3 revolute kinematic pairs and 1 prismatic kinematic pair is shown in the figure, where AB ⊥ CE and FD ⊥ CE. The T-shaped link CDEF is constructed such that the slider B can cross the point D, and CE is sufficiently long. For the given lengths as shown, the mechanism is



(GATE-22_SET-1)

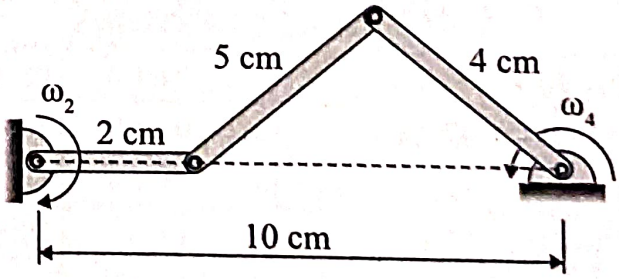
(a) a Grashof chain with links AG, AB, and CDEF completely rotatable about the ground link FG

(b) a non-Grashof chain with all oscillating links

(c) a Grashof chain with AB completely rotatable about the ground link FG, and oscillatory links AG and CDEF

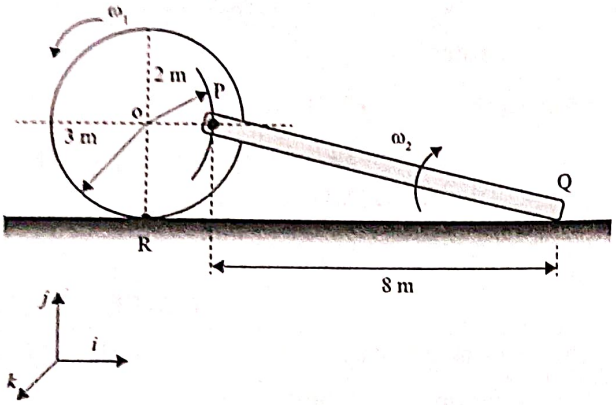
(d) on the border of Grashof and non-Grashof chains with uncertain configuration(s)

37. In the configuration of the planar four-bar mechanism at a certain instant as shown in the figure, the angular velocity of the 2 cm long link is ω_2 = 5 rad/s. Given the dimensions as shown, the magnitude of the angular velocity ω_4 of the 4 cm long link is given by _____ rad/s (round off to 2 decimal places).



(GATE-22_SET-2)

38. The figure shows a wheel rolling without slipping on a horizontal plane with angular velocity ω_1. A rigid bar PQ is pinned to the wheel at P while the end Q slides on the floor. What is the angular velocity ω_2 of the bar PQ? **(GATE_ME-23)**



(a) $\omega_2 = 2\omega_1$ (b) $\omega_2 = \omega_1$

(c) $\omega_2 = 0.5\omega_1$ (d) $\omega_2 = 0.25\omega_1$

KEY & Detailed Solutions				
ONE MARK QUESTIONS				
01. (b)	02. (d)	03. (a)	04. (d)	05. (c)
06. (d)	07. (c)	08. (b)	09. (d)	10. (a)
11. (c)	12. (a)	13. (c)	14. (d)	15. (b)
16. (c)	17. (c)	18. (a)	19. (d)	20. (a)
21. (d)	22. 20	23. (c)	24. (a)	
25. (d)	26. (b)	27. 1	28. 1	29. (b)
30. (b)	31. (d)	32. (a)	33. (c)	34. (a)
35. 120	36. (c)			
TWO MARKS QUESTIONS				
01. (b)	02. (c)	03. (b)	04. (a)	05. (c)
06. (c)	07. (d)	08. (a)	09. (d)	10. (c)
11. (c)	12. (b)	13. (b)	14. (c)	15. (d)
16. (a)	17. (c)	18. (a)	19. (b)	20. (b)
21. (d)	22. (d)	23.0.618	24. 1.2558	
25. 117.6	26. (c)	27. 1400	28. (c)	29. 1
30. 0.267	31. 243.3	32. (d)	33. (a)	34. (a)
35. 2	36. (a)	37. 1.25	38. (d)	

One Mark Solutions

01. Ans: (b)

Sol: Link 2 rotates counter clockwise. Identify the I_{24}. Direction of the velocity of I_{24} gives the direction of rotation of link 2.

02. Ans: (d)

Sol: It is 2nd or 3rd Inversion of single slider – crank chain which gives quick return motion

03. Ans: (a)

Sol: P = Shortest link

S = Longest link

If shortest link P is fixed then we get double crank mechanism.

04. Ans: (d)

Sol: Mechanical advantage is the reciprocal of velocity ratio. Velocity ratio at this configuration is zero being the dead center position. Hence mechanical advantage in this configuration is infinite '∞"

05. Ans: (c)

Sol: Grubler's equation, $DOF = 3(N-1) - 2P_1$

N = Number of links

P = Number of revolute pairs

$DOF = 3(N-1) - 2P_1$

$= 3(8-1) - 2(9) = 21 - 18 = 3$

06. Ans: (d)

Sol: At toggle position velocity ratio is 'zero' so mechanical advantage is '∞'.

07. Ans: (c)

Sol: ∴ Number of Inversions = number of links.

Inversion mechanism obtained by fixing different links at a time.

08. Ans: (b)

Sol: Gruebler's Criterion, $DOF = 3(N-1) - 2P_1$

N = Number of links,

P_1 = Number of rotary joints

Given

$\therefore DOF = 3(8-1) - (2 \times 10) = 21-20 = 1$

09. Ans: (d)

Sol: The mechanism is shown in the extreme position

$$QRR = \frac{180+2\alpha}{180-2\alpha} \Rightarrow \alpha = 30^\circ$$

$$\frac{O_1P}{O_1O_2} = \sin\alpha = \frac{1}{2} \Rightarrow O_1O_2 = d = 250 \text{ mm}$$

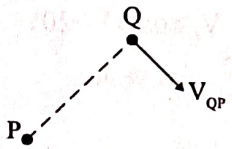
10. Ans: (a)

Sol: Indeterminate means super structure

$\therefore$ Mobility ≤ -1

11. Ans: (c)

Sol: If two points P and Q are on a planar rigid body, then velocity of point Q with respect to point P along the link will be zero because the distance between P and Q does not change.



Thus, the velocity of point Q with respect to point P will be perpendicular to PQ.

12. Ans: (a)

Sol: According to Grashof's law, a four bar mechanism has atleast one revolving link if the sum of the lengths of the largest and shortest links is sum of the other two links.

$$S + L \leq P + Q$$

Where, S = shortest link length,

L = largest link length,

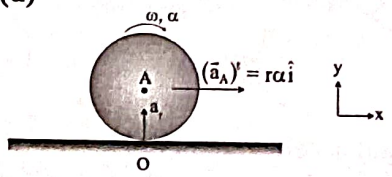
P and Q = length of other two links

13. Ans: (c)

Sol: It is the failure of Gruebler's equation of DOF because it does not consider the shape and dimensions of the mechanism.

14. Ans: (d)

Sol:



$\vec{a}_o = (\vec{a}_o)^t + (\vec{a}_o)^r$

where $(\vec{a}_o)^t$ is tangential component of acceleration of point 'o' and $(\vec{a}_o)^r$ is radial (or normal) component of acceleration of point 'o'.

$(\vec{a}_o)^t = (\vec{a}_{oA})^t + (\vec{a}_A)^t = -r\alpha\hat{i} + r\alpha\hat{i} = 0$

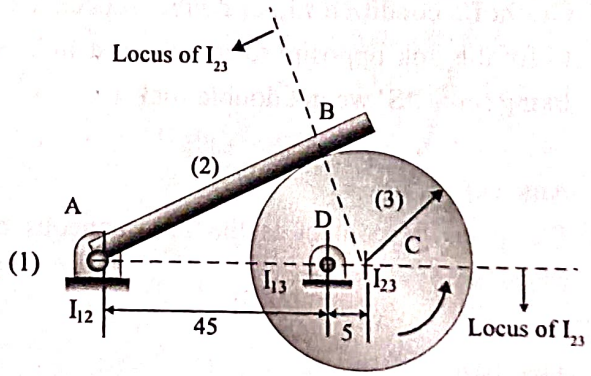
where $(\vec{a}_{oA})^t$ is tangential component of acceleration of point 'o' w.r.t to point A and $(\vec{a}_A)^t$ is tangential component of point A.

$(\vec{a}_o)_r = \omega^2 r\,\hat{j}$

15. Ans: (b)

Sol: I_{23} should be in the line joining I_{12} and I_{13}.

Similarly the link 3 is rolling on link 2.



So the I – Center I_{23} will be on the line perpendicular to the link – 2.

So the point C is the intersection of these two loci which is the center of the disc.

So $\omega_2(I_{12}, I_{23}) = \omega_3(I_{13}, I_{23})$

$\Rightarrow \omega_2 \times 50 = 1 \times 5$

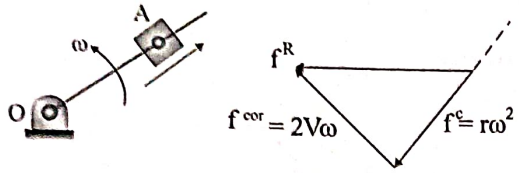
$\Rightarrow \omega_2 = 0.1$ rad/sec

16. Ans: (c)

Sol: Given :

$\omega = 2$ rad/sec, $\alpha = 0$

$V = 0.75$ m/sec , $OA = r = 1$ m



Centrifugal acceleration, $f_c = r\omega^2 = 4$ m/sec^2

[As $\alpha = 0$, tangential acceleration, $f^t = 0$]

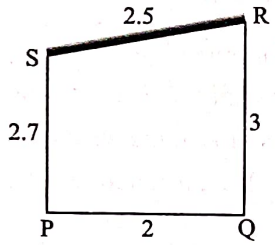
$f^{cor} = 2V\omega = 3$ m/sec^2

Resultant acceleration,

$f^R = \sqrt{4^2 + 3^2} = 5$ m/sec^2

17. Ans: (c)

Sol:



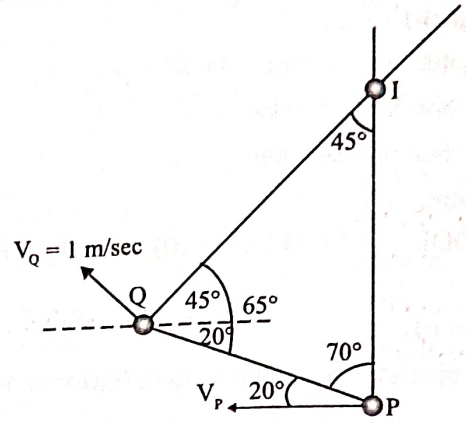
The given dimensions of the linkage satisfies Grashof's condition to get double rocker. We need to fix the link opposite to the shortest link. So by fixing link 'RS' we get double rocker.

18. Ans: (a)

Sol: The point of contact is the instantaneous centre whose velocity is zero

19. Ans: (d)

Sol: Refer the figure shown below, By knowing the velocity directions instantaneous centre can be located as shown. By knowing velocity (magnitude) of Q we can get the angular velocity of the link, from this we can get the velocity of 'P using sine rule.



'I' is the instantaneous centre.

From sine rule

$$\frac{PQ}{\sin 45} = \frac{IQ}{\sin 70} = \frac{IP}{\sin 65}$$

$$\frac{IP}{IQ} = \frac{\sin 65^\circ}{\sin 70^\circ}$$

$$V_Q = IQ \times \omega = 1 \Rightarrow \omega = \frac{V_Q}{IQ}$$

$$V_P = IP \times \omega = \frac{IP}{IQ} \times V_Q = \frac{\sin 65^\circ}{\sin 70^\circ} \times 1 = 0.9645$$

Alternate solution:

For a rigid link, $\overline{AB}$ = constant

$\vec{V}_{PQ} = 0$

$\therefore V_P \cos 20 = V_Q \cos(45 - 20)$

$\Rightarrow V_P = \frac{\cos 25}{\cos 20} = 0.96$ m/s

20. Ans: (a)

Sol: Given links satisfy Grashof's criterion's $(l + s < p + q)$ The shortest link is fixed so the resulting mechanism is a double crank mechanism where l = longest link, s = shortest link.

21. Ans: (d)

Sol: Mating of spur gear teeth forms higher pair and Revolute joint is a lower pair.

22. Ans: 20

Sol: Velocity of P = rω = 10 m/sec

$$\omega = \frac{V_p}{R} = \frac{10}{R}$$

Velocity of Q = 2Rω

$$= 2R \times \frac{10}{R} = 20 \text{ m/sec}$$

23. Ans: (c)

Sol: No .of Links, L = 4

No. of class 1 pairs $J_1 = 3$

No. of class 2 pairs $J_2 = 1$ (Between gears)

No. of dof $= 3(L-1) - 2J_1 - J_2 = 2$

24. Ans: (a)

Sol: The direction of Coriolis component is obtained by rotating the linear velocity vector in the direction of angular velocity by 90°.

Its magnitude = $2 V_{Q/p} \omega_2$.

25. Ans: (d)

Sol: $\vec{V}_Q = \vec{V}_P + \vec{V}_{PQ}$

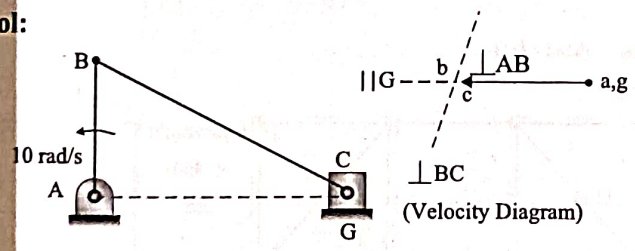
$= \vec{V}_P + \vec{\omega} \times \vec{r}_{PQ}$

26. Ans: (b)

Sol: Gruebler's equation.

27. Ans: 1

Sol:



From the velocity diagram when crank is perpendicular to the line of stroke, the velocity of slider = velocity of crank and angular velocity of connecting rod is zero.

$\omega_2 = 10$ rad/s

At this position, i.e. crank angle θ = 90°

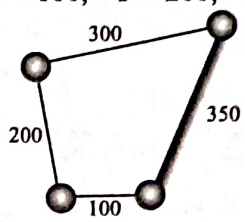
$V_{slider} = r\omega_2 = 10 \times 100$ mm/s

∴ Slider velocity = 1 m/s

28. Ans: 1

Sol: Links 100, 200, 300 and 350 mm

L = 350, S = 100, P = 200, Q = 300



∴ L + S = 450

P + Q = 500

∴ (L + S) < (P + Q) → Class –I / Grashof's chain

Fixed link = 350 mm = Adjacent to shortest

∴ Crank-Rocker Mechanism

∴ Number of link making full rotation is one. (shortest link)

29. Ans: (b)

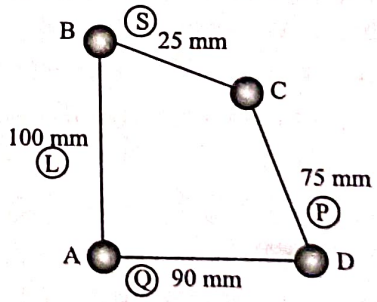
Sol: Oldham coupling is the third inversion of double slider crank chain. It is used when the driving and driven shafts have transverse / lateral misalignment of their axis. It does not alter the angular velocity.

30. Ans: (b)

Sol: Given :

S = 25 mm, L = 100 mm,

P = 75 mm, Q = 90 mm,



∴ L + S = 125

P + Q = 165

∴ (L + S) < (P + Q) – Class – I chain

As per Grashof's criterion,

For Double-Crank Mechanism, Fixed Link is Shortest link i.e., BC.