Subject Code

- Any -

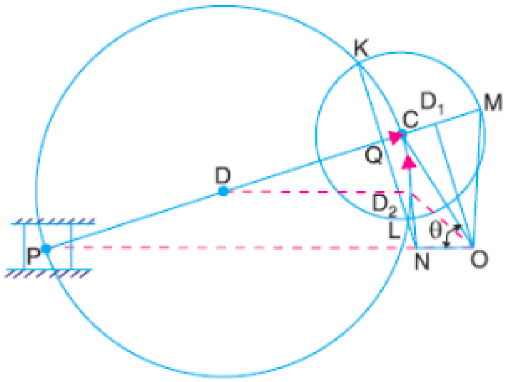
Chapter Name

- Any -

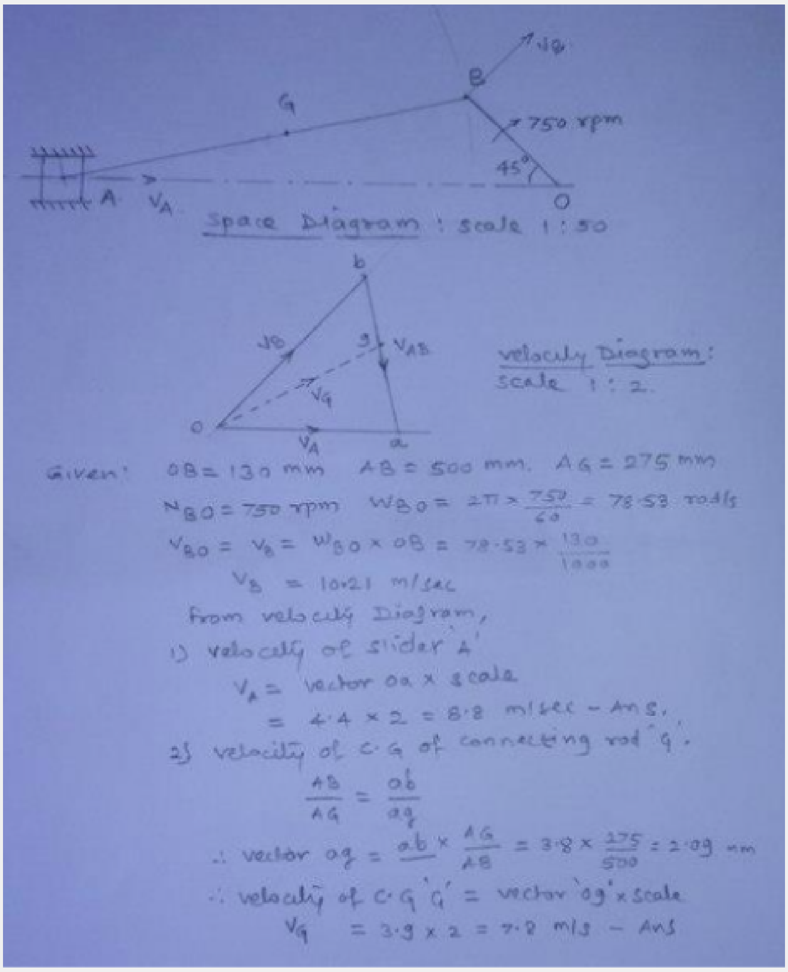
Apply

Examination: 2017 SUMMER

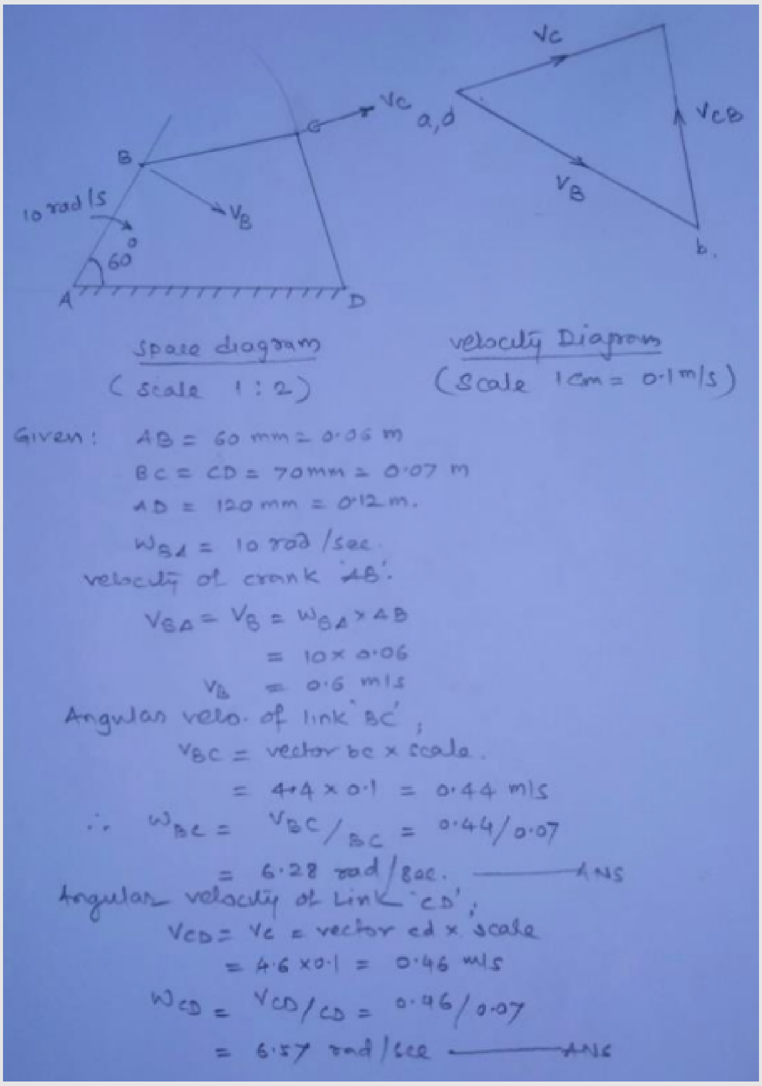
Que.No	Marks	
Q 1 d)	2	Question: **Define centripetal and tangential acceleration.** Answer: **Centripetal acceleration:** The centripetal acceleration is the rate of change of tangential velocity. When an object is moving with uniform acceleration in circular direction, it is said to be experiencing the centripetal acceleration. **Tangential acceleration:** Tangential acceleration is a measure of how the tangential velocity of a point at a certain radius changes with time. Tangential acceleration is just like linear acceleration, but it's particular to the tangential direction, which is relevant to circular motion. ---
Q 1 e)	2	Question: **Find the velocity of point B and midpoint C of link AB shown in Figure (1).** Answer: **Velocity of point B & C :** Vb = AB x wAB = 0.35 x 50 = 17.5 m/s Vc = AC x wAB = 0.175 x 50 = 8.75 m/s ---

Que.No	Marks	
Q 2 b)	2	Question: **Explain with neat sketch how to find the velocity of a slider in slider crank mechanism by Klein's construction.** Answer: **Velocity of a slider in a slider crank mechanism by Klein's construction method**  Let *OC* be the crank and *PC* the connecting rod of a reciprocating steam engine, as shown in Fig. below. Let the crank makes an angle θ with the line of stroke *PO* and rotates with uniform angular velocity ω rad/s in a clockwise direction. First of all, draw OM perpendicular to OP; such that it intersects the line PC produced at M. The triangle OCM is known as Klien's velocity diagram. In this triangle OCM, OM may be regarded as a line perpendicular to PO, CM may be regarded as a line parallel to PC, (since it is the same line) and CO may be regarded as a line parallel to CO. op_1 represents v_{PO} (*i.e.* velocity of *P* with respect to *O* or velocity of cross-head or piston *P*) and is perpendicular to *OP*, and c_1p_1 represents v_{PC} (*i.e.* velocity of *P* with respect to *C*) and is parallel to *CP*. --

<table>
<tr><th>Que.No</th><th>Marks</th><th></th></tr>
<tr><td>Q 3 c)</td><td>4</td><td>
Question:
In slider crank mechanism, the length of crank OB and connecting rod AB are 130 mm and 500 mm respectively. The centre of gravity G of the connecting rod is 275 mm from slider A. The crank speed is 750 rpm in clockwise. When crank has turned 45 from inner dead centre position determine (i) velocity of slider ‘A’ (ii) velocity of centre of gravity of connecting rod ‘G’.

Answer:


</td></tr>
</table>

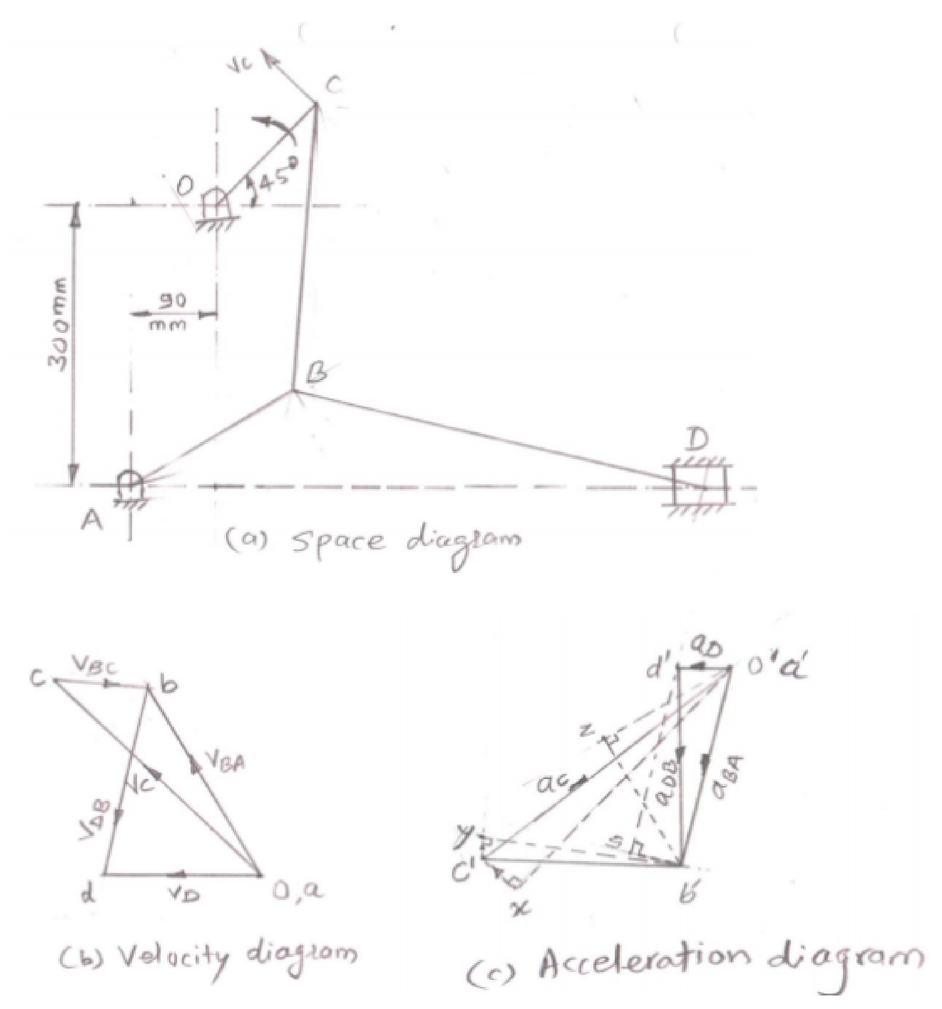
Que.No	Marks	
Q 4 b)	4	Question: **In a four bar mechanism ABCD link AD is fixed and the crank AB rotates at 10 radians per second in clockwise, lengths of the links are AB = 60 mm, BC = CD = 70 mm, DA = 120 mm, when angle DAB = 60° and both B and C lie on the same side of AB, find angular velocities of BC and CD link.** Answer:  --

<table>
<tr><th>Que.No</th><th>Marks</th><th></th></tr>
<tr><td>Q 5 b)</td><td>8</td><td>

Question:

In the toggle mechanism as shown in Fig. (2), D is constrained to move on a horizontal path. The dimensions of various links are AB = 200 mm, BC = 300 mm, OC = 150 mm and BD = 450 mm. The crank OC is rotating in a counter clockwise direction at a speed of 180 rpm. Find, for given configuration (1) velocity and (2) acceleration of ‘D’.

Answer:



1.Velocity of slider ‘D’ = vector ad = 1.6 m/s

2. Acceleration of slider ‘D’ = vector a’d’ = 9.0 m/s²

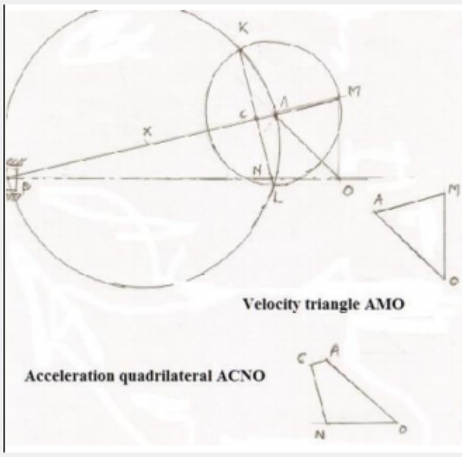
</td></tr>
</table>

Examination: 2017 WINTER

<table>
<tr><th>Que.No</th><th>Marks</th><th></th></tr>
<tr><td>Q 2 c)</td><td>4</td><td>
Question:
Define linear velocity, angular velocity, absolute velocity and state the relation between linear velocity and angular velocity

Answer:
<table>
<tr><th>Term</th><th>Definition</th><th>Mathematical/representation (optional)</th></tr>
<tr><td>Linear velocity</td><td>Rate of change of linear displacement per unit time</td><td>$V = \frac{d_x}{d_t}$ m/sec</td></tr>
<tr><td>Angular velocity</td><td>Rate of change of angular displacement per unit time</td><td>$\omega = \frac{d_\theta}{d_t}$ rad/sec</td></tr>
<tr><td>Absolute velocity</td><td>Velocity of any point with respect any point fixed point</td><td>V_{ao} ; velocity of point a w.r.t. o</td></tr>
</table>
Relation between linear and angular velocity: V = ω.r

</td></tr>
<tr><td>Q 2 d)</td><td>4</td><td>
Question:
Explain the Klein’s construction to determine velocity and acceleration of single slider crank mechanism

Answer:


klein’s construction
1) Draw the basic diagram with the angle made by crank , crank (AO) and connecting rod (AP) with dimensions and scale.
2) Extend the connecting rod upto the vertical line of the crank circle and mark intersection point M, the triangle created ΔOAM is the velocity triangle.
3) Bisect the connecting rod at X.
4) Draw the circle with radius equal to XA or XB.
5) Draw the circle with Centre as “A” and radius equal to AM.
6) Both circles will intersect each other at two points (K, L), join these two points.
7) This line will intersect the connecting rod at point “C” and line of stroke at point “N”.
Quadrilateral OACN is the acceleration diagram. This is required acceleration diagram of the links

If ωAO is the angular velocity of the crank, then Linear velocity’s of the links is given byVAO = ωAO x AO, VAP = ωAO x AM, VPO = ωAO x MO Acceleration of the links is given bya r AO = ω 2 AO x AO, a r AP = ω 2 AO x AC, a t AP = ω 2 AO x CN, aPO = ω 2 AO x NO

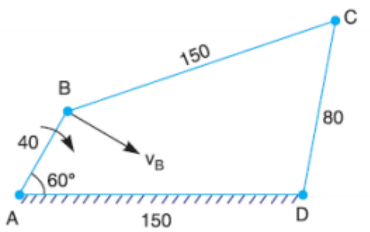
</td></tr>
</table>

<table>
<tr><th>Que.No</th><th>Marks</th><th></th></tr>
<tr><td>Q 3 a)</td><td>4</td><td>

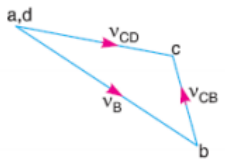
Question:

In a four bar chain ABCD, AD is fixed and is 150 mm long. The crank AB is 40 mm long and rotates at 120 r.p.m. clockwise, while the link CD = 80 mm oscillates about D. BC and AB are of equal length. Find the angular velocity of link CD when angle BAD = 60.

Answer:



Space diagram (All dimensions in mm).



Velocity diagram.

Given : $N_{BA} = 120$ r.p.m. or $\omega_{BA} = 2\,\pi \times 120/60 = 12.568$ rad/s

Since the length of crank $AB = 40$ mm $= 0.04$ m, therefore velocity of B with respect to A or velocity of B, (because A is a fixed point),

$$v_{BA} = v_B = \omega_{BA} \times AB = 12.568 \times 0.04 = 0.503 \text{ m/s}$$

vector $ab = v_{BA} = v_B = 0.503$ m/s

By measurement, we find that

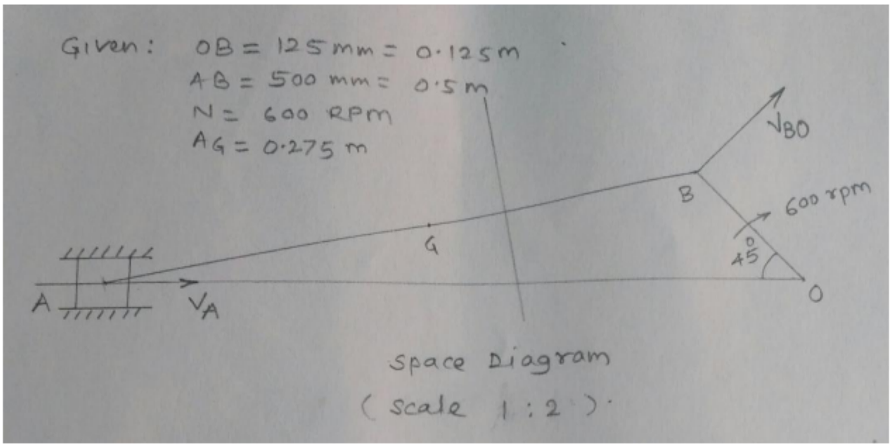
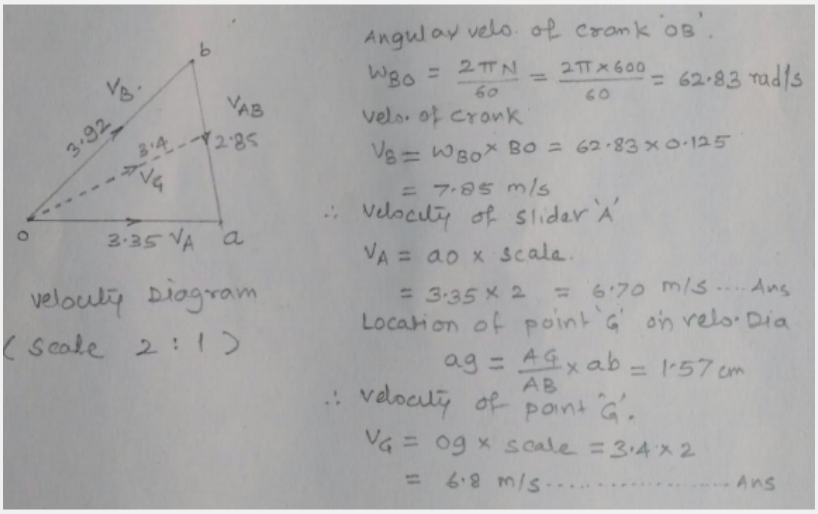
$$v_{CD} = v_C = \text{vector } dc = 0.385 \text{ m/s}$$

We know that $CD = 80$ mm $= 0.08$ m

$\therefore$ Angular velocity of link CD,

$$\omega_{CD} = \frac{v_{CD}}{CD} = \frac{0.385}{0.08} = 4.8 \text{ rad/s (clockwise about } D)$$

</td></tr>
</table>

Que.No	Marks	
Q 3 b)	4	Question: **In a slider crank mechanism, the length of crank OB and connecting rod AB are 125 mm and 500 mm respectively. The centre of gravity G of the connecting rod is 275 mm from the slider. The crank speed is 600 rpm clockwise. When the crank has turned 45 from the inner dead centre position, determine : (i) Velocity of slider 'A', (ii) Velocity of the point 'G' graphically.** Answer:   ---

Que.No	Marks	
Q 5 a)	8	

Question:

The crank of a slider crank mechanism rotates clockwise at a constant speed of 300 rpm. The crank is 150 mm and the connecting rod is 600 mm long. Determine : (i) linear velocity and acceleration of the mid-point of the connecting rod, and (ii) angular velocity and angular acceleration of the connecting rod, at a crank angle of 45 from inner dead centre position.

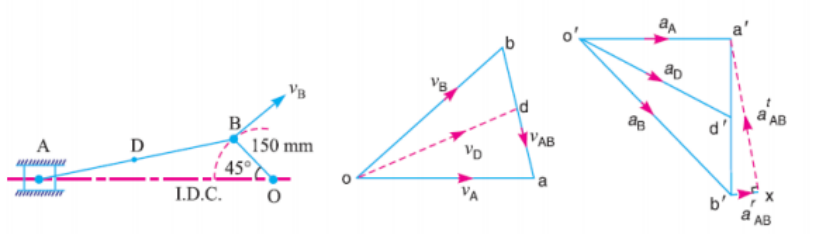
Answer:

Given : N_{BO} = 300 r.p.m. or $\omega_{BO} = 2\pi \times 300/60 = 31.42$ rad/s; OB = 150 mm = 0.15 m ; BA = 600 mm = 0.6 m

We know that linear velocity of B with respect to O or velocity of B,

$$v_{BO} = v_B = \omega_{BO} \times OB = 31.42 \times 0.15 = 4.713 \text{ m/s}$$

...(Perpendicular to BO)



Space diagram. Velocity diagram. Acceleration diagram.

In order to find the velocity of the midpoint D of the connecting rod AB, divide the vector ba at d in the same ratio as D divides AB, in the space diagram. In other words,

$bd / ba = BD/BA$

Note: Since D is the midpoint of AB, therefore d is also midpoint of vector ba.

Join od. Now the vector od represents the velocity of the midpoint D of the connecting rod *i.e.* V_D.

By measurement, we find that

$$\mathbf{V_D = \text{vector } od = 4.1 \text{ m/s}}$$

Acceleration of the midpoint of the connecting rod

We know that the radial component of the acceleration of B with respect to O or the acceleration of B,

$$a^r_{BO} = a_B = \frac{v^2_{BO}}{OB} = \frac{(4.713)^2}{0.15} = 148.1 \text{ m/s}^2$$

and the radial component of the acceleraiton of A with respect to B,

$$a^r_{AB} = \frac{v^2_{AB}}{BA} = \frac{(3.4)^2}{0.6} = 19.3 \text{ m/s}^2$$

In order to find the acceleration of the midpoint D of the connecting rod AB, divide the vector $a'\,b'$ at d' in the same ratio as D divides AB. In other words

$$b'd' / b'a' = BD / BA$$

Note: Since D is the midpoint of AB, therefore d' is also midpoint of vector b' a'. Join o' d'. The vector o' d' represents the acceleration of midpoint D of the connecting rod i.e. aD.

By measurement, we find that aD = vector o' d' = 117 m/s2

Angular velocity of the connecting rod

We know that angular velocity of the connecting rod AB,

$$\omega_{AB} = \frac{v_{AB}}{BA} = \frac{3.4}{0.6} = 5.67 \text{ rad/s}^2 \text{ (Anticlockwise about } B\text{)} \textbf{ Ans.}$$

Angular acceleration of the connecting rod

From the acceleration diagram, we find that

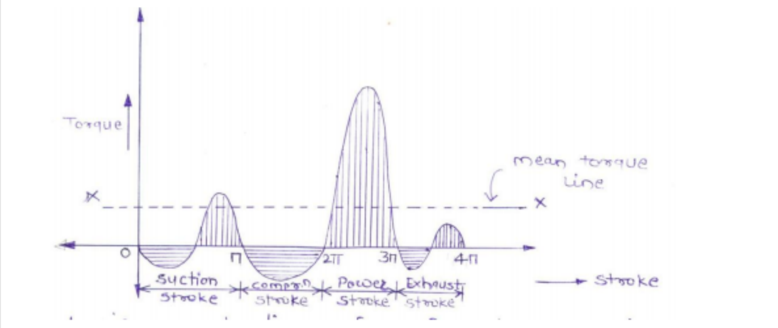
$$a^t_{AB} = 103 \text{ m/s}^2$$ ...(By measurement)

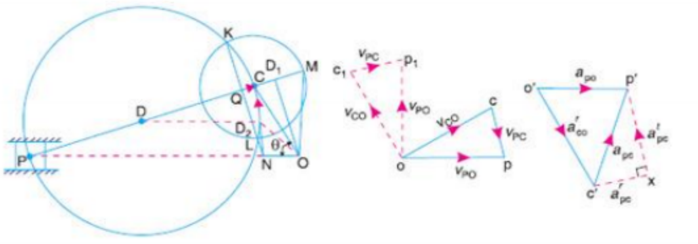
We know that angular acceleration of the connecting rod AB,

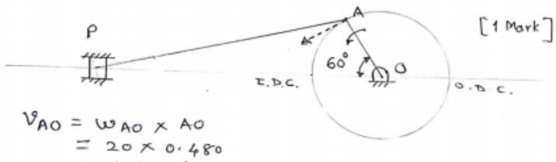
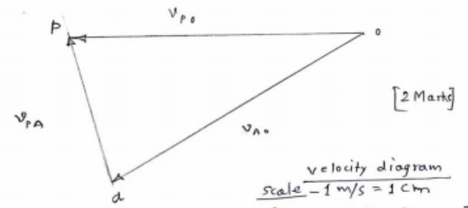
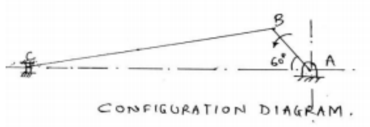
$$\alpha_{AB} = \frac{a^t_{AB}}{BA} = \frac{103}{0.6} = 171.67 \text{ rad/s}^2 \text{ (Clockwise about } B\text{)} \textbf{ Ans.}$$

Given: Lift = 40 mm Rise = ¼ x 360 = 900 Fall =1/6 x 360 = 600 Dwell = 1/10 x 360 =360

Examination: 2016 SUMMER

Que.No	Marks	
Q a)(ii)	4	Question: **Explain single cylinder 4-stroke I.C. engine using turning moment diagram.** Answer: A turning moment diagram for a four stroke cycle internal combustion engine, we know that in a four stroke cycle internal combustion engine, there is one working stroke after a crank has turned through two revolution i.e.7200 . Since the pressure inside the engine cylinder is less than the atmospheric pressure during suction stroke therefore a negative loop is formed. During the compression stroke, the work is done on gases, therefore a higher negative loop is obtained.  During the expansion or working stroke, the fuel burns and the gases expand, therefore a positive loop is obtained. In this stroke the work done is by the gases. During exhaust stroke, the work is done on the gases, therefore negative loop is formed. It may be noted that effect of inertia forces on the piston is taken is account. --
Q 2 c)	4	Question: **Define linear velocity, angular velocity, absolute velocity and state the relation between linear velocity and angular velocity.** Answer: Linear Velocity: It may be defined as the rate of change of linear displacement of a body with respect to the time. Since velocity is always expressed in a particular direction, therefore it is a vector quantity. Mathematically, linear velocity, v = ds/dt Angular Velocity: It may be defined as the rate of change of angular displacement with respect to time. It is usually expressed by a Greek letter ɷ (omega). Mathematically, angular velocity, ɷ = dϴ /dt Absolute Velocity: It is defined as the velocity of any point on a kinematic link with respect to fixed point. Relation between v and ɷ: V = r. ɷ Where V = Linear velocity. ɷ = angular velocity. r = radius of rotation. --

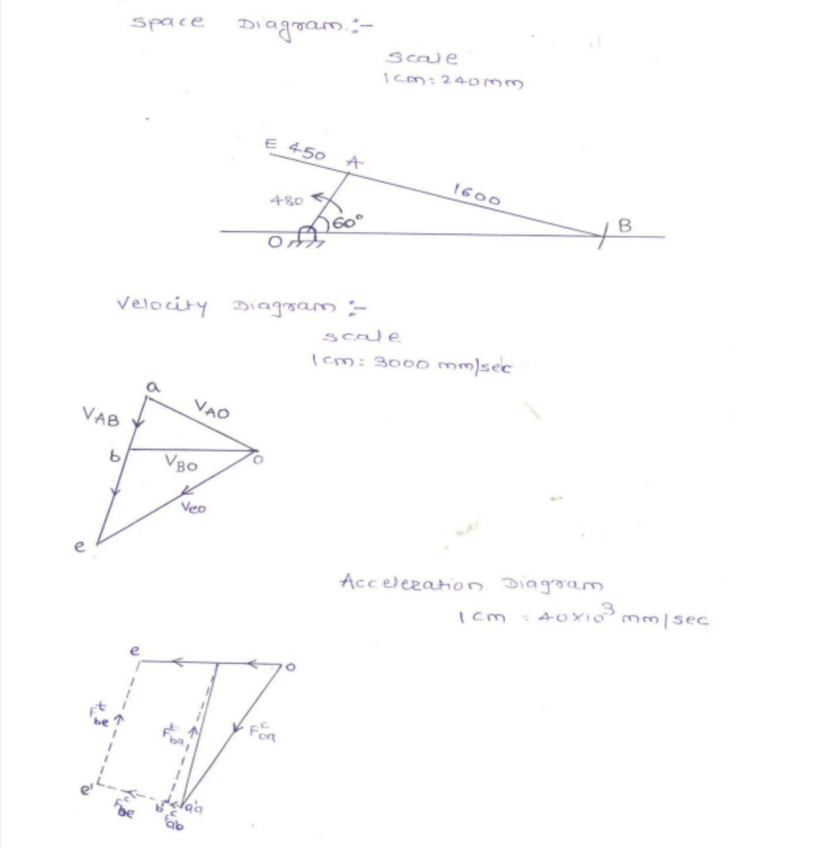
Que.No	Marks	
Q 2 d)	4	Question: **Explain the Klein's construction to determine velocity and acceleration of single slider crank mechanism.** Answer: Let *OC* be the crank and *PC* the connecting rod of a reciprocating steam engine, as shown in Fig. Let the crank makes an angle θ with the line of stroke *PO* and rotates with uniform angular velocity ω rad/s in a clockwise direction. The Klien's velocity and acceleration diagrams are drawn as discussed below:  (*a*) Klien's acceleration diagram. (*b*) Velocity diagram. (*c*) Acceleration diagram. ***Klien's velocity diagram*** First of all, draw *OM* perpendicular to *OP*; such that it intersects the line *PC* produced at *M*. The triangle *OCM* is known as ***Klien's velocity diagram***. In this triangle *OCM*, *OM* may be regarded as a line perpendicular to *PO*, *CM* may be regarded as a line parallel to *PC*, and ...(∵ It is the same line.) *CO* may be regarded as a line parallel to *CO*. We have already discussed that the velocity diagram for given configuration is a triangle OCP as shown in Fig. If this triangle is rotated through 90°, it will be a triangle oc1 p1, in which oc1 represents VCO (i.e. velocity of C with respect to O or velocity of crank pin C) and is parallel to OC, op1 represents VPO (i.e. velocity of P with respect to O or velocity of cross-head or piston P) and is perpendicular to OP, and c1p1 represents VPC (i.e. velocity of P with respect to C) and is parallel to CP. A little consideration will show that the triangles oc1p1 and OCM are similar. Therefore, $\frac{oc_1}{OC} = \frac{op_1}{OM} = \frac{c_1p_1}{CM} = \omega \text{ (a constant)}$ $\frac{v_{CO}}{OC} = \frac{v_{PO}}{OM} = \frac{v_{PC}}{CM} = \omega$ $v_{CO} = \omega \times OC\,;\ v_{PO} = \omega \times OM, \text{ and } v_{PC} = \omega \times CM$ Thus, we see that by drawing the Klein's velocity diagram, the velocities of various points may be obtained without drawing a separate velocity diagram. Klien's acceleration diagram: The Klien's acceleration diagram is drawn as discussed below: 1. First of all, draw a circle with C as centre and CM as radius. 2. Draw another circle with PC as diameter. Let this circle intersect the previous circle at K and L. 3. Join KL and produce it to intersect PO at N. Let KL intersect PC at Q. This forms the quadrilateral CQNO, which is known as Klien's acceleration diagram. We have already discussed that the acceleration diagram for the given configuration is as shown in Fig. We know that (i) o'c' represents CO ar (i.e. radial component of the acceleration of crank pin C with respect to O) and is parallel to CO; (ii) c'x represents PC ar (i.e. radial component of the acceleration of crosshead or piston P with respect to crank pin C) and is parallel to CP or CQ; (iii) xp' represents PC at (i.e. tangential component of the acceleration of P with respect to C) and is parallel to QN (because QN is perpendicular to CQ); and (iv) o'p' represents aPO (i.e. acceleration of P with respect to O or the acceleration of piston P) and is parallel to PO or NO. A little consideration will show that the quadrilateral o'c'x p' is similar to quadrilateral CQNO . Therefore, $\frac{o'c'}{OC} = \frac{c'x}{CQ} = \frac{xp'}{QN} = \frac{o'p'}{NO} = \omega^2 \text{ (a constant)}$ --

Que.No	Marks	
Q 3 a)	4	Question: **In a slider-crank mechanism, the crank is 480 mm long and rotates at 20 rad/sec in the counter-clockwise direction. The length of the connecting rod is 1600 mm. when the crank turns 60 from the inner-dead centre. Determine the velocity of the slider by relative velocity method.** Answer: Q 3(a) Slider Crank mechanism Crank = 480 mm long = OA = 0.480 m Connecting rod = 1600 mm long = AP ω_{AO} = 20 rad/s Scale 1 : 20  [1 Mark] $V_{AO} = \omega_{AO} \times AO$ $= 20 \times 0.480$ $= 9.6$ m/s  [2 Marks] velocity diagram scale – 1 m/s = 1 cm Velocity of slider = $v_{po} = \vec{PO}$ = 9.5 m/s [1 mark] --
Q 3 b)	4	Question: **In a slider crank mechanism, crank AB = 20 mm & connecting rod BC = 80 mm. Crank AB rotates with uniform speed of 1000 rpm in anticlockwise direction. Find (i) Angular velocity of connecting rod BC (ii) Velocity of slider C. When crank AB makes an angle of 60 degrees with the horizontal. Draw the configuration diagram also. Use analytical method.** Answer: Data- Crank AB=20mm; Connecting rod BC=80mm; N_{BA}= 1000 rpm (anticlockwise) Crank angle = θ= 60° ; n = l/r = 80/20 =4  [1 Mark] Angular velocity of crank = $\omega_{BA} = 2\pi N/60 = \frac{2 X \pi X 1000}{60}$ = 104.71 rad/sec Angular velocity of connecting rod = $\omega_{BC} = \frac{\omega \cos\theta}{n}$ $= \frac{104.71 X \cos 60^0}{4}$ =13.08 rad/sec …[1 Mark] Velocity of slider C = Vc = ω r $\left[sin\theta + \frac{\sin 2\theta}{2n}\right]$ = 104.71 X .02[sin 60 + $\frac{\sin 120}{2 X 4}$] = 2.04 m/s …………………….. [2 Marks] --

Que.No	Marks	
Q 5 a)	8	(see answer below)

Question:

Answer:



Calculations:

i) Velocity of crank AO:

V_{AO} = (r X ω) X (480 X 20)

$V_{AO} = 9600 mm/sec$

Velocity of connectingrod (AB)

$V_{AB} = l(ab) X Scale = 1.6 X 3000$

$V_{AB} = 4800 mm/sec$

Velocity of Slider :

$V_{BO} = l(bo) X Scale = 3.2 X 3000$

$V_{BO} = 9600 mm/sec$

Velocity of Extended link :

$V_{BE} = l(be) X Scale = 4.5 X 3000$

$V_{BE} = 13500 mm/sec$

Now,

Calculations for acceleration Diagram:

$$f^c_{OA} = \frac{(\text{velocity of crank}^2)}{\text{length of crank}} = \frac{(9600)^2}{480} = 192 X 10^3 \text{ mm/sec}$$

$$f^c_{AB} = \frac{(\text{velocity of rod}^2)}{\text{length of rod}} = \frac{(4800)^2}{1600} = 14.4 X 10^3 \text{ mm/sec}$$

$$f^c_{BE} = \frac{(\text{velocity of Extended link}^2)}{\text{length of crank}} = \frac{(13500)^2}{2050} = 88.90 X 10^3 \text{ mm/sec}$$

To be find:

1. **Acceleration of slider:**
   $a_{bo} = l(bo) X Scale = 1.6 X 40 X 10^3$
   $a_{bo} = 64 X 10^3 mm/sec^2$
2. **The Acceleration of point E:**
   $a_{oe} = l(oe) X Scale = 3.4 X 40 X 10^3$
   $a_{oe} = 136 X 10^3 mm/sec^2$
3. **Acceleration of link AB:**

a_{ab} = l(ab) X Scale = 4.3 X 40 X 10^3

a_{ab} = 172 X 10 mm/sec^2

Examination: 2016 WINTER

Que.No	Marks	
Q 2 c)	4	

Question:

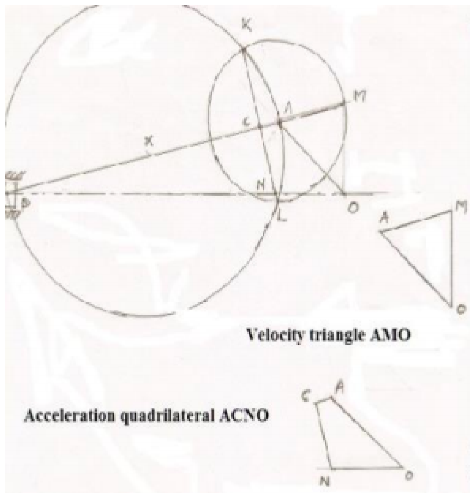
Explain Klein's construction to determine velocity and acceleration of different links in single slider crank mechanism.

Answer:

Klein's construction

a) For velocity of different links

b) For acceleration of different links



klein's construction

1) Draw the basic diagram with the angle made by crank , crank (AO) and connecting rod (AP) with dimensions and scale.
2) Extend the connecting rod upto the vertical line of the crank circle and mark intersection point M, the triangle created ΔOAM is the velocity triangle.
3) Bisect the connecting rod at X.
4) Draw the circle with radius equal to XA or XB.
5) Draw the circle with Centre as "A" and radius equal to AM.
6) Both circles will intersect each other at two points (K, L), join these two points.
7) This line will intersect the connecting rod at point "C" and line of stroke at point "N".

Quadrilateral OACN is the acceleration diagram. This is required acceleration diagram of the links

----

Que.No	Marks	
Q 2 d)	4	

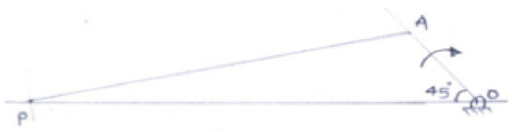
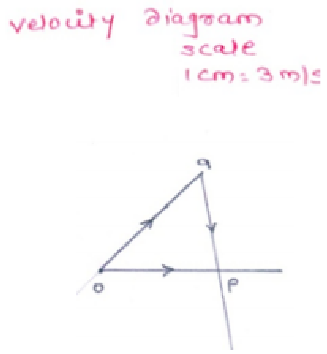
Question:

Define the terms: (i) Linear velocity (ii) Angular velocity (iii) Absolute velocity (iv) Relative velocity

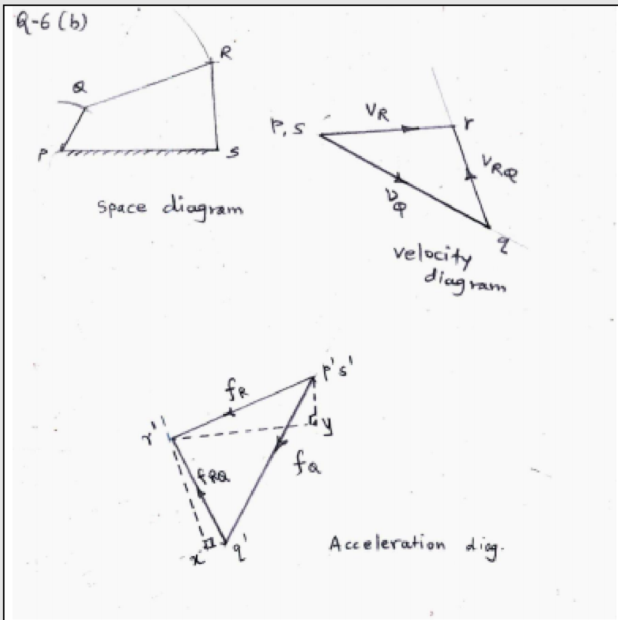
Answer:

Term	**Definition**	**Mathematical/representation (optional)**
Linear velocity	Rate of change of ***linear displacement*** per unit time	$V = \frac{d_x}{d_t}$ m/sec
Angular velocity	Rate of change of ***angular displacement*** per unit time	$\omega = \frac{d_\theta}{d_t}$ rad/sec
Absolute velocity	Velocity of any point with respect any point ***fixed point***	V_{ao} ; velocity of point a w.r.t. o
Relative velocity	Velocity of any point with respect to ***any other some point on the same link.***	V_{ab} ; velocity of point a w.r.t. b

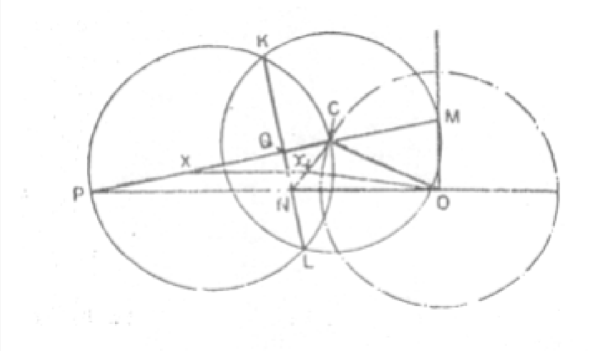
----

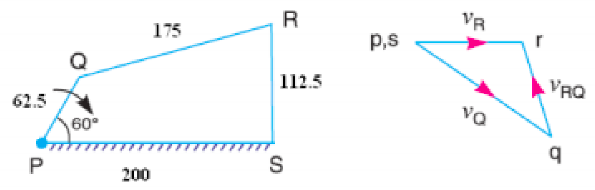
Que.No	Marks	
Q 3 b)	4	Question: **The crank and connecting rod of steam engine are 0.5m and 2m long respectively. The crank makes 180r.p.m. in clockwise direction. When it has turned through 45° from I.D.C. Find the velocity of piston and angular velocity of connecting rod by relative velocity method.** Answer: **Relative Velocity Method.** **Given Data:** **Crank = 0.5m** **Connecting rod=2m** **N= 180 rpm** **$\Theta = 45^0$** **A) Space diagram:** **Scale:** **1cm= 0.25m**  $\omega = \frac{2\Pi N}{60}$ $\frac{2\Pi X180}{60}$ **ω = 18.84 rad/s** **Calculations:**  1)V_{OA}= rω = 0.5 X 18.84 **V_{OA} = 9.42 m/s ….1 mark** **B)Velocity diagram:** **Scale:** **1 cm=3m/s** **2) Velocity of piston:** Vp= L(op) X scale =2.8 X3 **Vp=8.4 m/s …..ans** **3) Angular velocity of connecting rod:** $\omega = \frac{Vap}{length\ of\ AP} = \frac{l(ap) X\ Scale}{2} = \frac{2.2X3}{2}$ **ω= 3.3 rad/sec…..ans** ---

Que.No	Marks	
Q 5 a)	8	Question: **In a slider crank mechanism the length of crank and connecting rod are 100mm and 40mm respectively. The crank rotates uniformly at 600 rpm clockwise. Then crank has turned through 45° from I.D.C. Find by analytical method. (i) Velocity and acceleration of slider (ii) Angular velocity and angular acceleration of connecting rod.** Answer: Radius of crank , r=100 mm = 0.1m speed. N= 600 rpm ,ω= 2πN/60=62.83 rad/sec Length of connecting rod, l=400 mm=0.4m (40 mm is printing mistake) Obliquity ratio, n=l/r =400/100= 4, Crank angle ,θ= 45° Velocity of slider Vp= $\omega r(\sin\theta + \frac{\sin 2\theta}{2n})$ =5.225 m/s Acceleration of slider fp = $\omega^2 r(\cos\theta + \frac{\cos 2\theta}{n})$ =279.15 m/s^2 Angular velocity of connecting rod ω_{pc} = (ω cos θ)/n = 11.107 rad/sec Angular acceleration of connecting rod α_{pc} = $(-\omega^2 \sin\theta)/n$ = -697.89 rad/sec^2 ***[Note- If student has taken l=40,(due to printing mistake in QP) which is practically not possible, but values of answers in that case will be Vp=12.29 m/s ;fp= 279.15 m/s^2; ω_{pc}=111.07 rad/sec; α_{pc} =6978.86 rad/s^2 , which may be acceptable.]*** ---

Que.No	Marks	
Q 6 b)	8	Question: **PQRS is a four bar chain with link PS fixed. The lengths of links are PQ = 62.5mm, QR = 175mm, RS = 112.5mm and PS = 200mm, The crank PQ rotates at 10 rad/sec clockwise. Draw velocity and acceleration diagram, when angle QPS = 60° and Q and R lie on the same side of PS. Find the angular velocity and angular acceleration of links QR and RS.** Answer:  Calculations- V_{QP} ■ ω_{QP} X PQ =10 X 0.0625 = 0.625 m/s From Velocity diagram, By measurement, V_{RQ} ■0.333 m/s,; ω_{QR} = V_{RQ} /RQ ■0.333/0.175 ■1.9 rad/s (Anti clockwise)...1M By measurement, V_{RS} ■0.426 m/s,; ω_{RS} = V_{RS} /SR ■0.426/0.1125 ■3.78 rad/s (clockwise).....1M Find out radial acceleration of each link by using formula -V^2/length of link Fr_{QP} =6.25 m/s^2 ; fr_{RQ} = 0.634 m/s^2 ; fr_{RS} = 1.613 m/s^2 From acceleration diagram, measure all tangential components (ft) Angular acceleration of link QR , α_{QR} = ft RQ /QR =4.1/0.175= 23.43 rad/s^2 (Anti clockwise)...1M Angular acceleration of link RS , α_{RS}= ft RS /SR =5.3/0.1125= 47.1 rad/s^2 (Anti clockwise) ...1M --

Examination: 2015 SUMMER

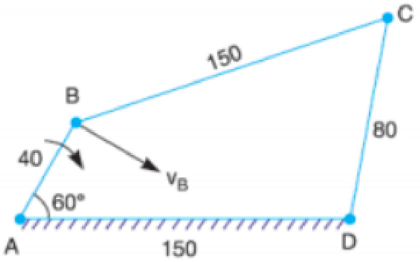
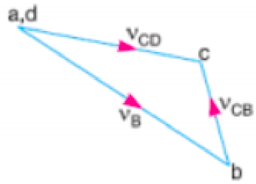
Que.No	Marks	
Q 2 c)	4	Question: **Define linear velocity, angular velocity, absolute velocity and state the relation between linear velocity and angular velocity.** Answer: **Linear Velocity** It may be defined as the rate of change of linear displacement of a body with respect to the time. Since velocity is always expressed in a particular direction, therefore it is a vector quantity. Mathematically, linear velocity, $v = ds/dt$ **Angular Velocity** It may be defined as the rate of change of angular displacement with respect to time. It is usually expressed by a Greek letter ω (omega). Mathematically, angular velocity, $\omega = \theta d/dt$ **Absolute Velocity** It is defined as the velocity of any point on a kinematic link with respect to fixed point. **Relation between v and ω:** $V = r.\ \omega$ Where V = Linear velocity ω =angular velocity r = radius of rotation --
Q 2 d)	4	Question: **Describe stepwise procedure for determination of velocity and acceleration by Klein's construction with suitable data.** Answer: **Steps in Klein's construction :** Klein's construction is a simpler construction to get velocity and acceleration diagrams. For example : for reciprocating engine mechanism OPC. draw a circle with PC as diameter as shown. and obtain velocity diagram OCM ie. produce PC to cut perpendicular to line of stroke in 'M' . Draw another circle with 'C' as center and "CM" as radius cutting the first circle in points K and L. Join "KL" which is the chord common to both the circles. Let it cuts PC and OP in "Q" and "N" respectively. Then "OCQN" is the required quadrilateral which is similar to acceleration diagram.  --

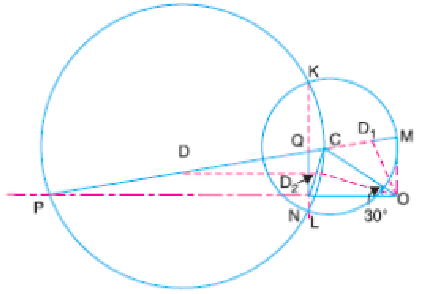
Que.No	Marks	
Q 3 e)	4	Question: **PQRS is a four bar chain with PS fixed length of links are PQ = 62.5 mm, QR =175 mm, RS = 112.5 mm, PS = 200 mm. The crank PQ rotate at 10 rad/sec. in clockwise direction. Determine the angular velocity of point R, graphically by using relative velocity method.** Answer: Assume angle QPS = 60^0  (*a*) Space diagram. (*b*) Velocity diagram. V_{QP} = PQ x ω_{pq} = 0.0625 x 10 rad / sec = 0.625 m/s First of all, draw the space diagram to some suitable scale, as shown in Fig. Now the velocity diagram, as shown in Fig. is drawn as discussed below : 1. Since the link PS is fixed, therefore points p and s are taken as one point in the velocity diagram. Draw vector pq perpendicular to QP to some suitable scale, to represent the velocity of Q with respect to P or simply velocity of Q (*i.e* V_{qp} or V_q) such that vector pq = V_{qp} = V_q = 0.625 m/s 2. Now from point q, draw vector qr perpendicular to RQ to represent the velocity of R with respect to Q (*i.e.* V_{rq}) and from point s, draw vector sr perpendicular to RS to represent the velocity of R with respect to S or simply velocity of R(*i.e.* V_{rs}, or V_r). The vectors qr and sr intersect at r By measurement, we find that $V_{rs} = V_r$ = vector sr = 0.43 m/s We know that RS = 112.5 mm = 0.1125 m ∴ Angular velocity of R = Ang. Velo. of link RS (clockwise about S) $\omega_{RS} = \frac{V_{rs}}{RS} = \frac{0.43}{0.1125} = 3.82$ rad/s **Ans.** --

Que.No	Marks	
Q 5 a)	8	Question: **In reciprocating engine the crank is 250 mm long and connecting rod is 1000 mm long. The crank rotate at 150 rpm. Find velocity and acceleration of piston and angular velocity and angular acceleration of connecting rod when the crank makes an angle of 30° to IDC. Use analytical method.** Answer: **Solution of problem on Reciprocating Engine :** Given : r= 250 mm = 0.25 m , l= 1000 mm = 1 m , $\theta = 30°$; $N =$ 150 rpm $\omega = \pi \times 150 / 60 = 7.85$ rad/s **1. Velocity of piston** We know that ratio of the length of connecting rod and crank, $n = l / r = 1 / 0.25 = 4$ $\therefore$ Velocity of the slider, $v_P = \omega r \left(\sin\theta + \frac{\sin 2\theta}{2n} \right) = 7.85 \times 0.25 \left(\sin 30 + \frac{\sin 60°}{2 \times 4} \right)$ m/s $= 1.19$ m/s **Ans.** and acceleration of the slider, $a_P = \omega^2 . r \left(\cos\theta + \frac{\cos 2\theta}{n} \right) = (7.85)^2 \times 0.25 \left(\cos 30° + \frac{\cos 60°}{4} \right)$ m/s^2 $= 15.27$ m/s^2 **Ans.** **2. Angular velocity & Angular acceleration of Con Rod** We know that angular velocity of the connecting rod, $\omega_{PC} = \frac{\omega \cos\theta}{n} = \frac{7.85 \times \cos 30°}{4} = 1.67$ rad/s **Ans.** and angular acceleration of the connecting rod, $\alpha_{PC} = \frac{\omega^2 \sin\theta}{n} = \frac{(7.85)^2 \times \sin 30°}{4} = 7.7$ rad/s^2 **Ans.** ---

Examination: 2015 WINTER

Que.No	Marks	
Q 2 c)	4	Question: **Define the terms linear velocity, relative velocity, angular velocity and angular acceleration.** Answer: **Velocity:** It may be defined as the rate of change of linear displacement of a body with respect to the time. Since velocity is always expressed in a particular direction, therefore it is a vector quantity. Mathematically, linear velocity, $v = ds/dt$ **Relative velocity:** relative velocity is the velocity of an object or an observer B in the rest frame of another object or an observer A. Consider two bodies *A* and *B* moving along parallel lines in the same direction with absolute velocities v_A and v_B such that $v_A > v_B$, as shown in Fig. 7.1 (*a*). The relative velocity of *A* with respect to *B*, v_{AB} = Vector difference of v_A and $v_B = \overline{v_A} - \overline{v_B}$ **Angular velocity:** It may be defined as the rate of change of angular displacement with respect to time. It is usually expressed by a Greek letter ⌉(omega). Mathematically, angular velocity, $\omega = d\theta / dt$ **Angular acceleration:** It may be defined as the rate of change of angular velocity with respect to time. It is usually expressed by a Greek letter 〈 (alpha). Mathematically, angular acceleration, $\alpha = \frac{d\omega}{dt} = \frac{d}{dt}\left(\frac{d\theta}{dt}\right) = \frac{d^2\theta}{dt^2}$ ... $\left(\because \omega = \frac{d\theta}{dt}\right)$ --
Q 2 d)	4	Question: **For a single slider crank mechanism , state the formulae to calculate by analytical method – Also state the meaning of each term.** Answer: **i) Velocity of slider:** **Vp = w.r [sinθ + sin2θ/2n]** where, Vp - velocity of slider w- angular velocity θ – angle of crank to line of stroke 'PO' n- l/r = ratio of length of connecting rod to crank radius. **ii) Acceleration of slider:** **fp = w2 r(cos θ + cos2θ/n)** where, fp – acceleration of slider **iii) Angular velocity of connecting rod.:** **wpc = w cos θ / (n2 – sin2θ)1/2** Where, wpc is angular velocity of connecting rod **iv) Angular acceleration of connecting rod.:** **αpc = -w2sinθ (n2 -1)/ (n2 -sin2θ) 3/2** Where, αpc is angular acceleration of connecting rod. --

Que.No	Marks	
Q 3 a)	4	Question: **Space diagram 01 Mark, Velocity Diagram 02 marks , Calculations 01 Mark Note In QP length BC & AB are equal. Read length AD = length BC = 150 mm** Answer:  Space diagram (All dimensions in mm).  Velocity diagram. Given : N_{BA} = 120 r.p.m. or $\omega_{BA} = 2\pi \times 120/60 = 12.568$ rad/s Since the length of crank AB = 40 mm = 0.04 m, therefore velocity of B with respect to A or velocity of B, (because A is a fixed point), $v_{BA} = v_B = \omega_{BA} \times AB = 12.568 \times 0.04 = 0.503$ m/s vector $ab = v_{BA} = v_B = 0.503$ m/s By measurement, we find that $v_{CD} = v_C$ = vector dc = 0.385 m/s We know that CD = 80 mm = 0.08 m ∴ Angular velocity of link CD, $\omega_{CD} = \frac{v_{CD}}{CD} = \frac{0.385}{0.08} = 4.8$ rad/s (clockwise about D) ---
Q 3 b)	4	Question: **In a single slider crank mechanism, crank AB = 20 mm and connecting rod BC = 80 mm. Crank AB rotates with uniform speed of 1000 rpm in anticlockwise direction. Find (i) angular velocity of connecting rod BC and (ii) Velocity of slider C when crank AB makes angle of 60° with the horizontal.** Answer: Given: Crank AB = 20 mm = 0.02 m, C. R. BC = 80 mm = 0.08 m N = 1000 rpm, ωBA= 2πN/60 = 2π x 1000/60 = 104.7 rad/sec VBA = ωBA x AB = 104.7 x 0.02 = 2.09 m/s **From velocty diagram:** Velocity of C w.r.t. B - VCB = vector cb = 1.15 m/s Angular velocity of Connecting rod ‘BC’ ωCB = VCB / CB = 1.15/0.08 = 14.375 rad /sec Velocity of slider ‘C’ VC= vector ac = 2 m/sec ---

Que.No	Marks	
Q 5 a)	4	Question: **The crank and connecting rod of a reciprocating engine are 200 mm and 700 mm respectively. The crank is rotating in clockwise direction at 120 rad/s. Draw Klein's construction and find (i) Velocity and acceleration of the piston (ii) Angular velocity and angular acceleration of the connecting rod at the instant when the crank is at 30° to IDC (inner dead centre).** Answer: **Construction :**  ***1. Velocity and acceleration of the piston*** We know that the velocity of the piston *P*, $v_P = \omega \times OM = 120 \times 0.127 = 15.24$ m/s **Ans.** and acceleration of the piston *P*, $a_P = \omega^2 \times NO = (120)^2 \times 0.2 = 2880$ m/s^2 **Ans.** ***3. Angular velocity and angular acceleration of the connecting rod*** We know that the velocity of the connecting rod *PC* (*i.e.* velocity of *P* with respect to *C*), $v_{PC} = \omega \times CM = 120 \times 0.173 = 20.76$ m/s ∴ Angular acceleration of the connecting rod *PC*, $\omega_{PC} = \frac{v_{PC}}{PC} = \frac{20.76}{0.7} = 29.66$ rad/s **Ans.** We know that the tangential component of the acceleration of *P* with respect to *C*, $a^t_{PC} = \omega^2 \times QN = (120)^2 \times 0.093 = 1339.2$ m/s^2 ∴ Angular acceleration of the connecting rod *PC*, $\alpha_{PC} = \frac{a^t_{PC}}{PC} = \frac{1339.2}{0.7} = 1913.14$ rad/s^2 **Ans.** --