Subject Code : **17412** **Model Answer**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept

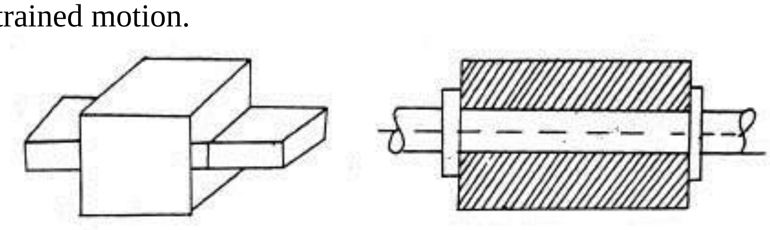
Q.1 (A) Attempt any SIX: (6×2 = 12)

(a) Enlist the types of constrained motion. Draw a label sketch of any one.

Ans.: **(List – 1 mark, Sketch of any one type – 1 mark.)**

Types of constrained motion:

(i) Completely constrained motion.
(ii) Incompletely constrained motion.
(iii) Successfully constrained motion.



completely constrained motion

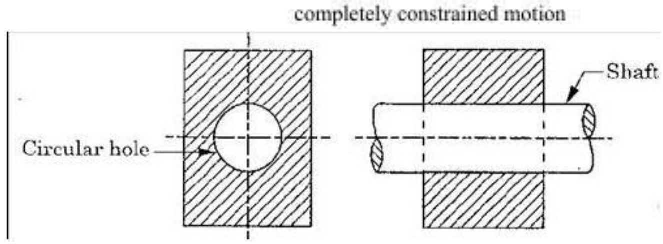


Fig: Incompletely constrained motion

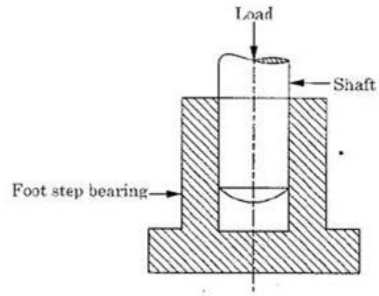


Fig: Successfully constrained motion.

(b) Define (i) Pressure angle (ii) Pitch point related to cam.

Ans.: **(1 mark for each definition)**

(i) Pressure angle: It is the angle between the direction of the follower motion and a normal to the pitch curve. This angle is very important in designing a cam profile. If the pressure angel is too large, a reciprocating follower will jam in its bearing.

(ii) Pitch point: It is point on pitch curve having the maximum pressure angle.

(c) How are drives classified?

Ans.: **(4 types – 2 marks)**

Classification of drives:

(i) Belt drives.
(ii) Chain drives.
(iii) Rope.
(iv) Gear drives.

(d) Write any two disadvantages of chain drive.

Ans: **(Any 2 disadvantages – 2 marks)**

Disadvantages of chain drives:

1. Manufacturing cost of chains is relatively high.
2. The chain drive needs accurate mounting and careful maintenance.
3. High velocity fluctuations especially when unduly stretched.
4. Chain operations are noisy as compared to belts.

(e) Define: (i) Coefficient of fluctuation of speed.
(ii) Coefficient of fluctuation of energy.

Ans.: **(1 mark for each definition)**

(i) **Coefficient of fluctuation of speed:** Coefficient of fluctuation of speed is defined as the ratio of the maximum fluctuation of speed to the mean speed. It is denoted by C_s.

Mathematically,

$$C_s = (N_1 - N_2) / N$$

Where, N_1 = maximum speed in rpm; N_2 =minimum speed in rpm; N = mean speed in rpm.

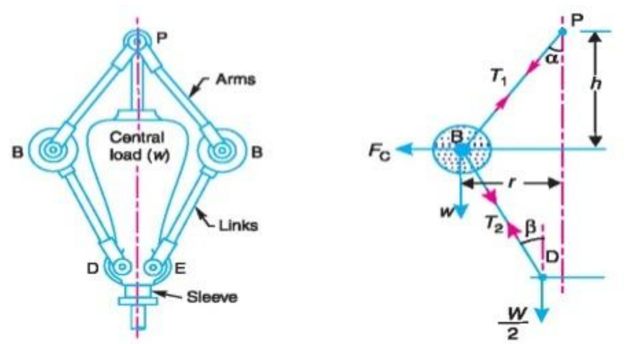
(ii) **Coefficient of fluctuation of energy:** Coefficient of fluctuation of energy may be defined as the ratio of the maximum fluctuation of energy to the work done per cycle. It is denoted by C_E.

Mathematically,

C_E = Maximum fluctuation of energy/ Work done per cycle.

(f) Draw line diagram of porter governor.

Ans.: **(Sketch – 1 mark, label - 1 mark)**



(g) State the application of (i) Disc brake (ii) Internal expanding brake.

Ans.: **(any one application of each brake: 1mark)**

(i) Disc brake: Used in two wheelers as well as in four wheelers.

(ii) Internal expanding brake: Used in motor cars, light trucks, two wheelers etc.

(h) Why is balancing of rotating parts necessary for high speed engines?

Ans.: **(Proper explanation or any two point of necessity- 2 marks)**

The high speed of engines and other machines is a common phenomenon now-a-days. It is, therefore, very essential that all the rotating and reciprocating parts should be completely balanced as far as possible. If these parts are not properly balanced, the dynamic forces are set up. These forces not only increase the loads on bearings and stresses in the various members, but also produce unpleasant and even dangerous vibrations. The balancing of unbalanced forces is caused by rotating masses, in order to minimize pressure on the main bearings when an engine is running.

Q.1 (B) Attempt any TWO: (2 ×4 = 8)

(a) State inversions of double slider crank chain. Explain Oldham's coupling with neat sketch.

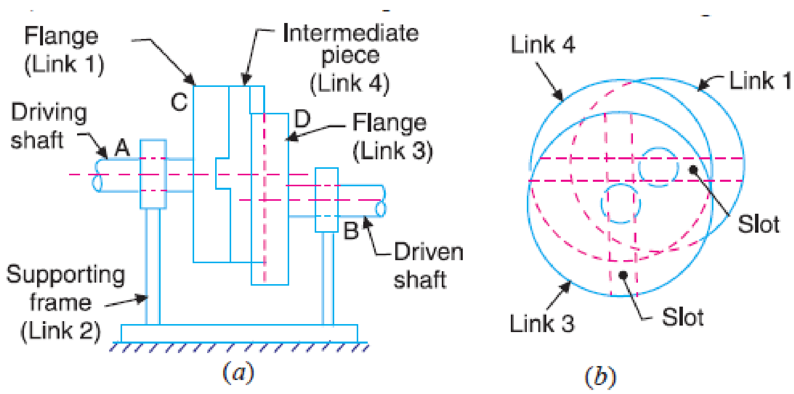
Ans.: **(List of inversions of double slider – 1 mark, Explanation – 1 mark, sketch – 2 marks)**

Inversions of double slider crank chain:

i. Scotch Yoke mechanism.
ii. Oldham’s coupling.
iii. Elliptical trammel.

Oldham's coupling:

An Oldham's coupling is used for connecting two parallel shafts whose axes are at a small distance apart. The shafts are coupled in such a way that if one shaft rotates, the other shaft also rotates at the same speed. This inversion is obtained by fixing the link 2, as shown in Fig. The shafts to be connected have two flanges (link 1 and link 3) rigidly fastened at their ends by forging. The link 1 and link 3 form turning pairs with link 2. These flanges have diametrical slots cut in their inner faces, as shown in Fig. The intermediate piece (link 4) which is a circular disc, have two tongues (i.e. diametrical projections) T1 and T2 on each face at right angles to each other. The tongues on the link 4 closely fit into the slots in the two flanges (link 1 and link 3). The link 4 can slide or reciprocate in the slots in the flanges.



Oldham's coupling.

When the driving shaft A is rotated, the flange C (link 1) causes the intermediate piece (link 4) to rotate at the same angle through\ which the flange has rotated, and it further rotates the flange D (link 3) at the same angle and thus the shaft B rotates. Hence links 1, 3 and 4 have the same angular velocity at every instant. A little consideration will show that there is a sliding motion between the link 4 and each of the other links 1 and 3.

(b) Explain: (i) Uniform pressure theory.
(ii) Uniform wear theory in clutches and bearing.

Ans.: **(Explanation of uniform pressure theory – 2 marks, Explanation of uniform wear theory – 2 marks)**

(i) Uniform pressure theory:

- When the mating component in clutch, bearing are new, then the contact between surfaces may be good over the whole surface.
- It means that the pressure over the rubbing surfaces is uniform distributed.
- This condition is not valid for old clutches, bearings because mating surfaces may have uneven friction.
- The condition assumes that intensity of pressure is same.

$P = W/A = \text{Constant}$; where, W= load, A= area

(ii) Uniform wear theory in clutches and bearings:

- When clutch, bearing become old after being used for a given period, then all parts of the rubbing surfaces will not move with the same velocity.
- The velocity of rubbing surface increases with the distance from the axis of the rotating element.
- It means that wear may be different at different radii and rate of wear depends upon the intensity of pressure (P) and the velocity of rubbing surfaces (V).
- It is assumed that the rate of wear is proportional to the product of intensity of pressure and velocity of rubbing surfaces.
- This condition assumes that rate of wear is uniform;

  P*r = Constant; where, P = intensity of pressure, r = radius of rotation.

(c) Compare cross belt drive and open belt drive on the basis of:
(i) Velocity ratio. (ii) Direction of driven pulley. (iii) Length of belt drives (iv) Application.

Ans.: **(Each point – 1 mark)**

Comparison between cross and open belt drive:

Sr. No.	Parameter	Cross belt drive	Open belt drive
01	Velocity ratio	High	Low
02	Direction of driven pulley	Same as driver pulley	Opposite to driven pulley
03	Length of belt drive	Long	Short
04	Application	Large amount of power to be transmitted	Less amount of power to be transmitted

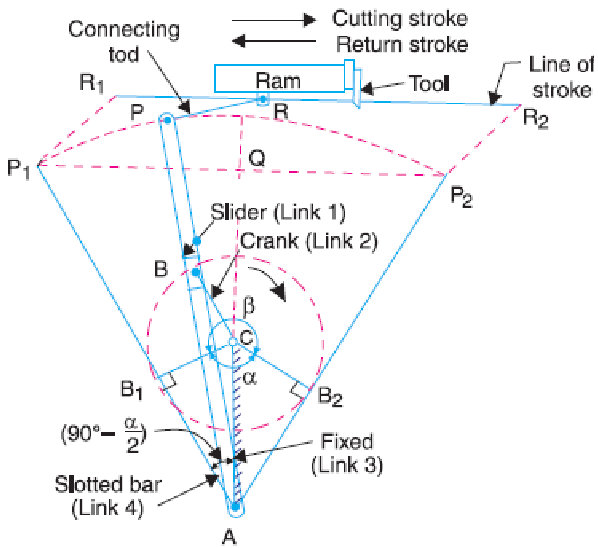
Q.2 Attempt any FOUR: (4 × 4 = 16)

(a) Draw a labeled sketch of quick return mechanism of shaper and explain its working.

Ans.: **(Two quick return mechanisms are used in shaper machine 1. Crank and slotted lever quick return mechanism and Whitworth quick return mechanism. Any one mechanism with proper explanation – 2 marks, sketch of mechanism – 2 marks. Here crank and slotted lever quick return mechanism's explanation is given)**

Crank and slotted lever quick return motion mechanism.

This mechanism is mostly used in shaping machines, slotting machines and in rotary internal combustion engines. In this mechanism, the link AC (i.e. link 3) forming the turning pair is fixed, as shown in fig. The link 3 corresponds to the connecting rod of a reciprocating steam engine. The driving crank CB revolves with uniform angular speed about the fixed centre C. A sliding block attached to the crank pin at B slides along the slotted bar AP and thus causes AP to oscillate about the pivoted point A. A short link PR transmits the motion from AP to the ram which carries the tool and reciprocates along the line of stroke R1R2. The line of stroke of the ram (i.e. R1R2) is perpendicular to AC produced.



In the extreme positions, *AP*1 and *AP*2 are tangential to the circle and the cutting tool is at the end of the stroke. The forward or cutting stroke occurs when the crank rotates from the position *CB*1 to *CB*2 (or through an angle β) in the clockwise direction. The return stroke occurs when the crank rotates from the position *CB*2 to *CB*1 (or through angle α) in the clockwise direction. Since the crank has uniform angular speed,

therefore,

$$\frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{\beta}{\alpha} = \frac{\beta}{360^\circ - \beta} \quad \text{or} \quad \frac{360^\circ - \alpha}{\alpha}$$

Since the tool travels a distance of $R_1 R_2$ during cutting and return stroke, therefore travel of the tool or length of stroke

$$= R_1R_2 = P_1P_2 = 2P_1Q = 2AP_1 \sin \angle P_1AQ$$

$$= 2AP_1 \sin\left(90^\circ - \frac{\alpha}{2}\right) = 2AP \cos\frac{\alpha}{2} \qquad \text{..... } (\because AP_1 = AP)$$

$$= 2AP \times \frac{CB_1}{AC} \qquad \text{... } \left(\because \cos\frac{\alpha}{2} = \frac{CB_1}{AC}\right)$$

$$= 2AP \times \frac{CB}{AC} \qquad \text{... } (\because CB_1 = CB)$$

(b) What are the types of kinematic pair? Give its examples.

Ans.: **(Any four types with one example – 4 marks.)**

Types of Kinematic Pairs.	Examples
A. According to nature	

of relative motion	
i. Sliding pair.	Piston and cylinder, Tail stock on the lathe bed etc.
ii. Turning pair.	A shaft with collars at both ends fitted into a circular hole, Cycle wheels turning over their axles etc.
iii. Rolling pair.	Ball and roller bearing.
iv. Screw pair.	A lead screw of a lathe with nut, Bolt with a nut etc.
v. Spherical pair	The ball and socket joint, attachment of car mirror, pen stand etc.
B. According to nature of contact	
i. Lower Pair.	All sliding pairs, turning pairs and screw pairs forms lower pair.
ii. Higher pair	A pair of friction discs, toothed gearing, belt and rope drives, ball and roller bearings, cam and followers are examples of higher pairs.
C. According to nature of mechanical arrangement	
i. Closed pair or self closed pair.	The lower pairs are self closed pairs.
ii. Open or force close pair.	Cam and follower.

(c) Define linear velocity, angular velocity, absolute velocity and state the relation between linear velocity and angular velocity.

Ans.: **(Each point – 1 mark)**

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, $\omega = d\Theta /dt$

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.

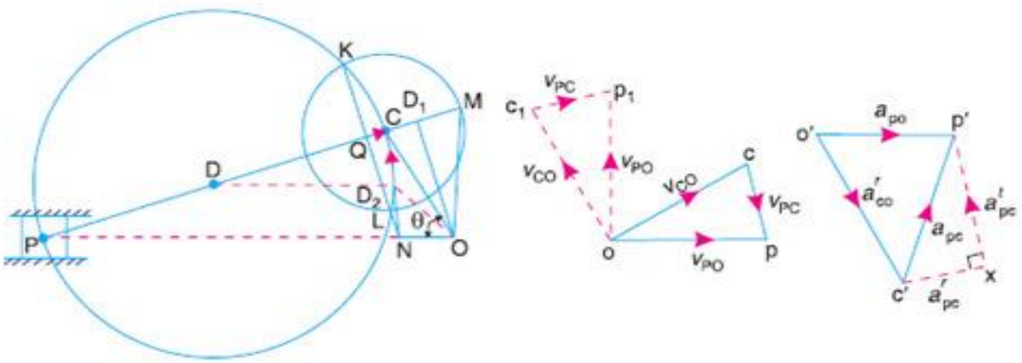
ω = angular velocity.

r = radius of rotation.

(d) Explain the Klein's construction to determine velocity and acceleration of single slider crank mechanism.

Ans.: **(Sketch – 2 marks, Explanation of velocity triangle – 1 mark, Explanation of acceleration diagram – 1 mark)**

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 V_{CO} (i.e. velocity of C with respect to O or velocity of crank pin C) and is parallel to OC, 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 c1p1 represents V_{PC} (i.e. velocity of P with respect to C) and is parallel to CP. A little consideration will show that the triangles oc_1p_1 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 a^r (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 a^r (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 a^t (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 a_{PO} (i.e. acceleration of P with respect to O or the acceleration of piston P) and is parallel to PO or NO.

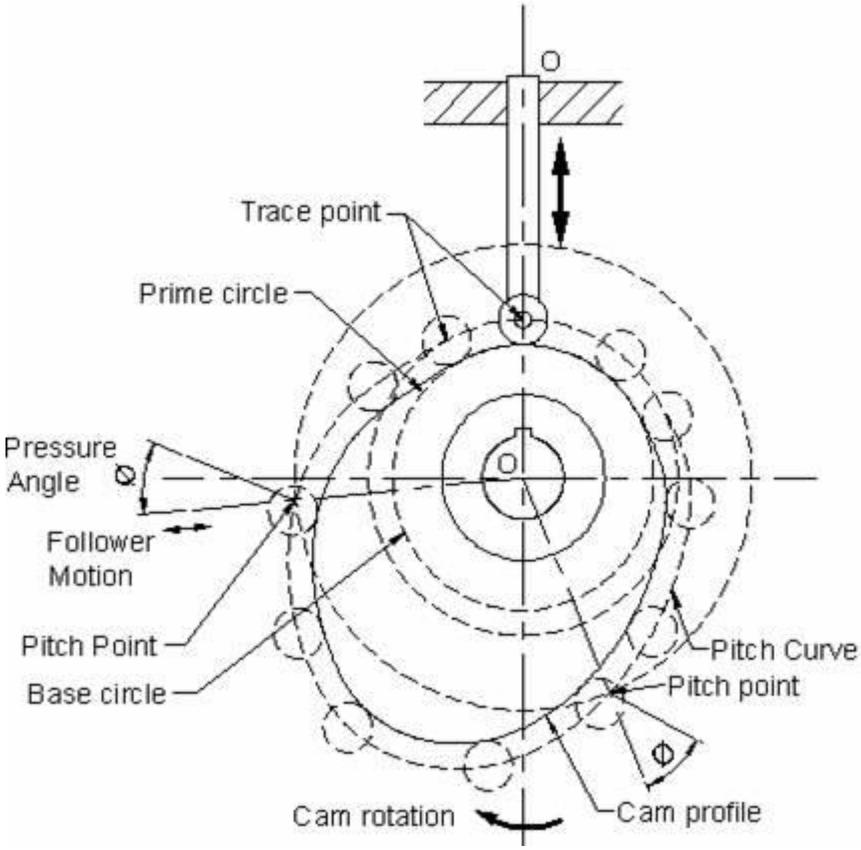
A little consideration will show that the quadrilateral o'c'x p' is similar to quadrilateral CQNO . Therefore,

$$\frac{o'c'}{OC} = \frac{c'x}{CQ} = \frac{xp'}{QN} = \frac{o'p'}{NO} = \omega^2 \text{ (a constant)}$$

(e) Draw neat sketch of radial cam with follower and show on it:

Ans.: **(Sketch and label of each given point – 4 marks)**

(i) Base circle. (ii) Pitch point. (iii) Prime Circle. (iv) Cam profile.



(f) A shaft runs at 80 rpm & drives another shaft at 150 rpm through belt drive. The diameter of the driving pulley is 600 mm. Determine the diameter of the driven pulley in the following cases:

(i) Taking belt thickness as 5 mm.

(ii) Assuming for belt thickness 5 mm and total slip of 4%.

Ans.: Given data;

N_1 = 80 rpm.

N_2 =150 rpm.

D_1= 600 mm.

S = 4 %

To find; D_2 =?;

(i) Case I: Taking t = 5 mm.

Velocity ratio, (V.R.) $N_2/N_1 = (D_1 + t)/ (D_2 + t)$…………… ……… **(1 mark)**

$150/80 = (600 + 5)/ (D_2 + 5)$

Therefore, diameter of driven pulley D_2 = 317.66 mm ~ 318mm……………. **(1 mark)**

(ii) Case II: Assuming for belt thickness 5 mm and total slip of 4%.

Velocity ratio, (V.R.) $N_2/N_1 = \{(D_1 + t)/ (D_2 + t)\} \times \{1- (S/100)\}$…. **(1 mark)**

$150/80 = \{(600 + 5) / (D_2 + 5)\} \times \{1- (4/100)\}$

Therefore, diameter of driven pulley D_2 = 304.76 mm ~ 305 mm….. **(1 mark)**

Q 3 -ATTEMPT ANY FOUR [16]

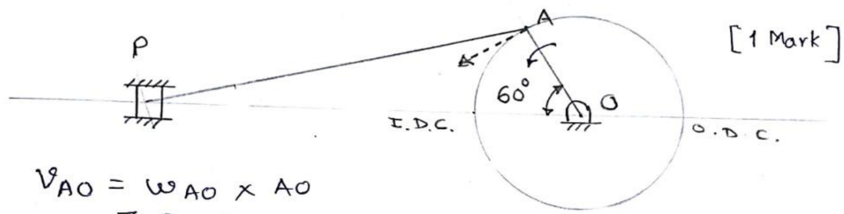
Q 3(a) Slider crank mechanism

Crank = 480 mm long = OA = 0.480 m

Connecting rod = 1600 mm long = AP

$\omega_{AO} = 20$ rad/s

Scale 1 : 20

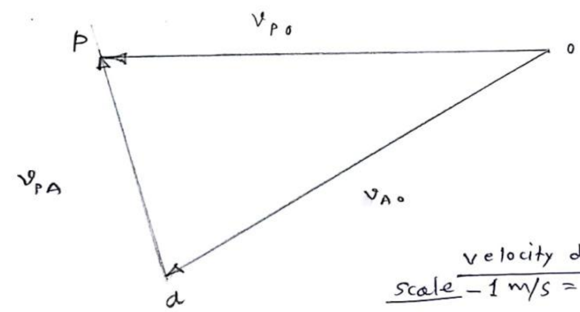


[1 Mark]

$v_{AO} = \omega_{AO} \times AO$

$= 20 \times 0.480$

$= 9.6$ m/s



[2 Marks]

velocity diagram

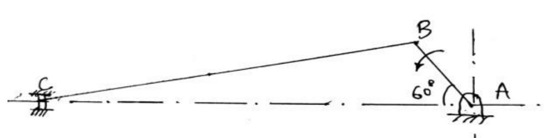
Scale – 1 m/s = 1 cm

Velocity of slider = $v_{PO} = \vec{PO} = 9.5$ m/s [1 mark]

(b) Slider crank mechanism (Analytical method)

Data- Crank AB=20mm; Connecting rod BC=80mm; N_{BA}= 1000 rpm (anticlockwise)

Crank angle = θ= 60° ; n = l/r = 80/20 =4



CONFIGURATION DIAGRAM.

[1 Mark]

Angular velocity of crank = $\omega_{BA} = 2\pi N/60 = \frac{2 \times \pi \times 1000}{60} = 104.71$ rad/sec

Angular velocity of connecting rod = $\omega_{BC} = \frac{\omega \cos\theta}{n}$

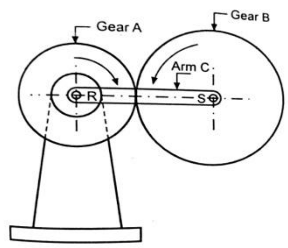
$= \frac{104.71 \text{ X } \cos 60^0}{4}$ =13.08 rad/sec …[1 Mark]

Velocity of slider C = Vc = ω r $\left[sin\theta + \frac{\sin 2\theta}{2n}\right]$

$= 104.71 \text{ X } .02[\ \sin 60 + \frac{\sin 120}{2 \, X \, 4}]$

= 2.04 m/s ………………..… [2 Marks]

(c) Epicyclic Gear train :- [sketch 2, explain 2]

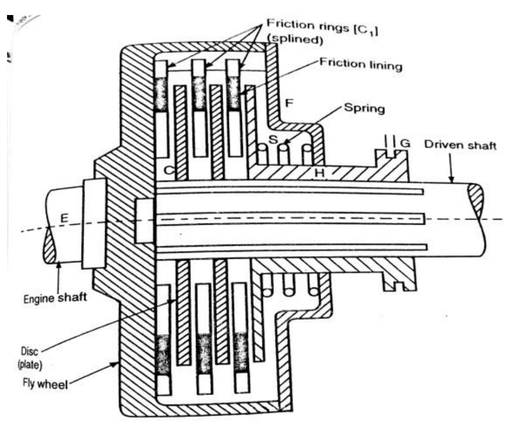


In case of Epicyclic Gear train, the axis of shafts on which gears are mounted may have a relative motion between them, unlike other gear trains. This gives advantage that, very high or low velocity ratio can be obtained compared to simple and compound gear trains; in the small space.

In above sketch, if gears A and B are rotating and arm RS is fixed, then it behaves like simple gear train. However, when Arm C rotates and gear A is fixed, then train becomes epicyclic. It is also known as planetary gear train.

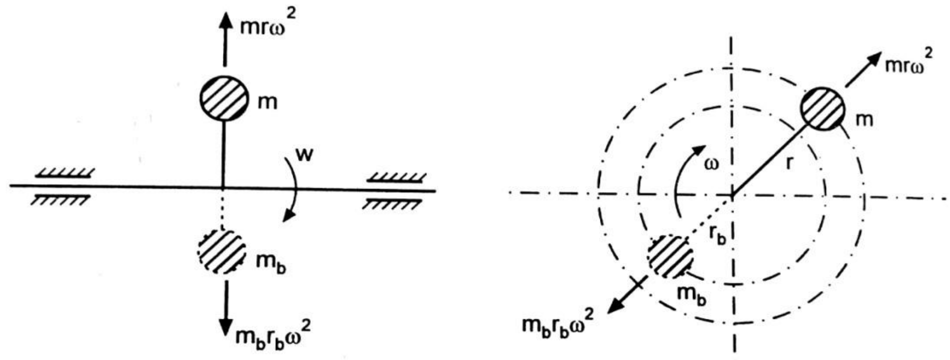
Applications- Differential gears of the automobiles, back gear of lathe, hoists, pulley blocks

(d) Multi plate clutch –- Sketch -- [3 Marks]



Applications- Automobiles like scooters, motorcycles, textile and paper industries, machine tools [1 M]

(e) Procedure of Balancing single rotating mass when disturbing mass in same plane



(a) Longitudinal positions of masses **(b) Angular positions of masses**

…………… [2M]

Fig. shows single rotating mass ‘m’ which is attached to a shaft rotating with angular velocity ‘ω’.
Let ‘r’ = distance of centre of gravity of ‘m’ from axis of rotation of shaft. Due to rotation of shaft, centrifugal force ‘$mr\omega^2$ ‘acts radially outwards due to inertia of mass. This force is called disturbing force which will produce bending moment on the shaft.
A balance mass m_b is introduced in the plane of rotation of disturbing mass, such that, it neutralizes the effect of inertia force due to disturbing mass.
Thus , the inertia forces of mass ‘m’ and mass ‘m_b’ must be equal and opposite.

$$mr\omega^2 = m_b r_b \omega^2$$

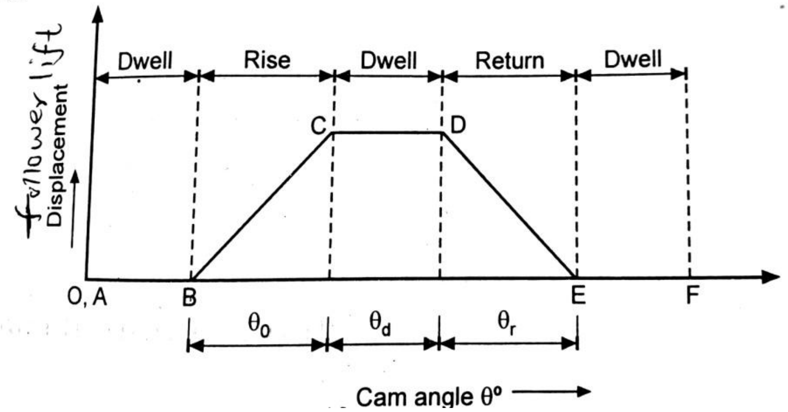
$$mr = m_b r_b.$$

Thus the balancing mass m_b is used at convenient radius r_b .Generally, r_b is considered as large as possible so that balance mass m_b required is very small. ….[2 M]

(f) Different types of follower motions –

The following during its travel may have one of the following motions:-
Uniform velocity, Simple harmonic motion, Uniform acceleration and retardation, Cycloidal motion ……. [2 M]

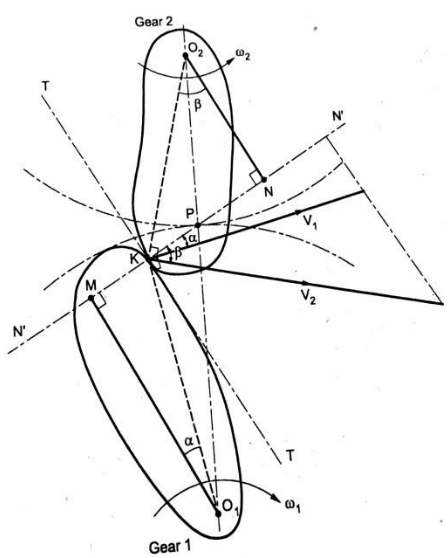
Displacement Diagram of Uniform Velocity



In above displacement diagram, abscissa (base) represents angular displacement of Cam in degrees (Cam Angle) and ordinate represents lift or stroke of follower in mm. In uniform velocity, slope is constant. The lines AB , CD and EF represent dwell period (no follower motion)and lines BC and DE represent rise and return stroke respectively, with uniform velocity. ………… [2M]

Q4- Attempt any FOUR [16]

(a) Law of Gearing [Sketch-2 and explain -2]



Consider the portions of two gear teeth in mesh. O_1 and O_2 are centre points.
Let K= point of contact
T T = Common tangent at point of contact K
N'N' = Common Normal at point of contact K
O_1M and O_2N are perpendicular to Common Normal N'N'.

V_1 and V_2 =Velocities at point K w. r. t. gear 1 and 2 respectively
If mating teeth to remain in contact while transmitting motion, components of velocities must be equal along N'N'.
So, $V_1 \cos \propto = V_2 \,COS\, \beta$
$(\omega 1 \times O1K) \cos \propto = (\omega 2 \times O2K) \cos \beta$
From triangles O1MK and O2NK putting values of cos ∝ and COS β
$\omega_1 \times O_1K \times \frac{O1M}{O1K} = \omega_2 \times O_2K \times \frac{O2N}{O2K}$
$\omega_1 \times O_1M = \omega_2 \times O_2N$
$\frac{\omega 1}{\omega 2} = \frac{O2N}{O1M}$ …………..(1)
Since O_1MP and O_2NP are similar triangles.

$\frac{O2N}{O1M} = \frac{O2P}{O1P}$ …………..(2)

From equations (1) and(2) , we get

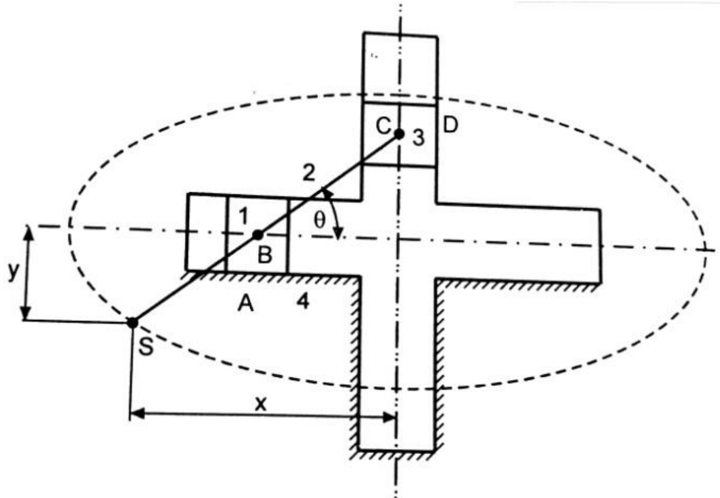
$\frac{\omega 1}{\omega 2} = \frac{O2P}{O1P}$

From this, it is proved that angular velocity ratio is inversely proportional to ratio of distance of fixed point 'P' ,which is pitch point. This gives constant angular velocity ratio.

In other words, the common normal at the point of contact between a pair of teeth must always pass through the pitch point for all positions of mating gears. This is the fundamental condition which must be satisfied while designing the profiles of teeth for gears. This is Law of Gearing or Condition of correct gearing.

(b) Elliptical trammel-

Since Elliptical trammel consist of two turning pairs and two sliding pairs, it is inversion of double slider crank chain.
This instrument is used for drawing ellipses. This inversion is obtained by fixing a slotted plate (link 4) as shown in fig. It has got two right angled grooves cut into it.
1-2 is turning pair 2-3 is turning pair
1-4 is sliding pair 3-4 is sliding pair [2 M]

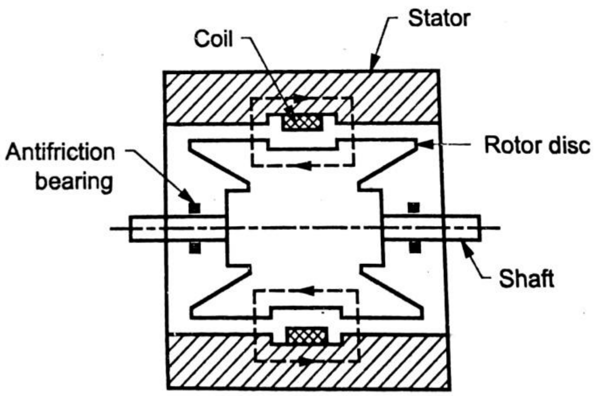


As the crank BC is rotated, any point on crank except midpoint of BC and point B and C will trace the ellipse. Midpoint of BC will trace a circle. The points B and C will move in straight line along the slot. …….[2M]

(c) Difference between Flywheel and Governor (Any 4 points – 4 Marks)

FLYWHEEL	GOVERNOR
1.Function- To control the speed variations caused by fluctuations of engine turning moment during a cycle.	Function- To regulate the mean speed of engine within prescribed limit when there are variations of load.
2 .Mathematically it controls $\frac{\delta N}{\delta t}$	2. Mathematically it controls δN
3. Flywheel acts as a reservoir; it stores energy due to its mass moment of inertia and releases energy when required during a cycle.	3. A governor regulates the speed by regulating the quantity of charge/working fluid of prime mover.
4.It regulates speed in one cycle only	4. It regulates speed over a period of time.
5.Flywheel has no control over supply of fluid/charge	5. Governor takes care of quantity of fluid
6. It is not an essential element of every prime mover. It is used when there are undesirable cyclic fluctuations.	6. It is an essential element of prime mover since varying demand of power is met by it.

(d) Construction and Working of Eddy current dynamometer [2 M+ 2M]



Sketch represents working principle of this transmission type dynamometer, to measure torque and hence power output of an engine.

- It consists of rotor disc made of steel or copper. The rotor shaft is supported in bearings and it is coupled to engine shaft.
- Stator is fitted with number of electromagnets and the stator cradles in the trunion bearings. When rotor rotates, it produces eddy currents in the stator due to magnetic flux by passage of field current in the electromagnets.
- These currents oppose the rotor motion, thus loading the engine.
- The torque is measured with the help of torque arm.
- This dynamometer requires some cooling arrangement since the eddy current generate heat.
- This dynamometer is compact and versatile; as it can measure high power output at all speeds. These are used to test automobile and aircraft engines.

(e) Multiplate disc clutch

Data:- Power=P = 55 KW = $55X10^3$ W ; N= 1800 rpm ; p = 160 KN/m^2 = 160 X 10^3 N/m^2
Internal radius R2 = 80 mm; External radius R1= $80/0.7$ =114.28 mm
Coefficient of friction $\mu = 0.1$
No. of plates needed to transmit torque = n = ??
Now using formula of power,

$$P = \frac{2\pi NT}{60}$$

$$55X10^3 = \frac{2 X 3.14 X 1800 X T}{60}$$

T= 291.79 N-m **……….[1 Mark]**

Considering uniform wear theory, for clutches, maximum pressure intensity is at minimum radius, i.e. $R_{min} = R_2$

$p_{max} = C / R_2$

$160 X 10^3 = C/ 0.08$

C= 12800 ……….**[1 Mark]**

Axial load W = $2\pi C(R1 - R2)$

= 2 X 3.142 X 12800 X(0.1142-0.08)

W =2756.96 N ……….**[1 Mark]**

Considering uniform wear theory, Torque transmitted by clutch

$T = \frac{1}{2}\mu W(R1 + R2)\ X\ n$

291.79 =$\frac{1}{2}$ X 0.1 X 2756.96 X (0.1142+0.08) X n

$n = 10.89 \approx 11$

$This\ is\ Number\ of\ pairs\ in\ contact.$

No. of plates needed is $n + 1 = 12$…….Ans ……….**[1 Mark]**

(f) Data-

m1= 4 kg	r1= 75 mm	θ1 = 45°	m1r1= 300 kg-mm
m2= 3kg	r2= 85 mm	θ2 = 135°	m2r2 = 265 kg-mm
m3= 2.5 kg	r3= 50 mm	θ3 = 240°	m3r3 = 125 kg-mm

Radius of balance mass = r = 75 mm

Let m=Balancing mass

Resolving horizontally,

$$\sum H = m1r1cos\theta1 + m2r2cos\theta2 + m3r3cos\theta3$$

= 300cos 45°+265 cos 135° +125 cos 240°

= -37.87 kg-mm [1 M]

Resolving vertically,

$$\sum V = m1r1sin\theta1 + m2r2sin\theta2 + m3r3sin\theta3$$

= 300sin 45°+265 sin 135° +125 sin240°

291.25 kg-mm [1M]

Resultant R= $\sqrt{(\Sigma H)^2 + (\Sigma V)^2}$

=$\sqrt{(-37.87)^2 + (291.25)^2}$

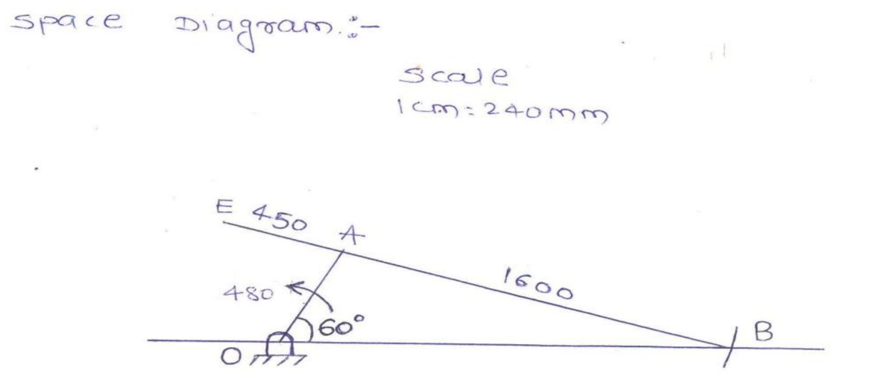
= 293.70 kg-mm

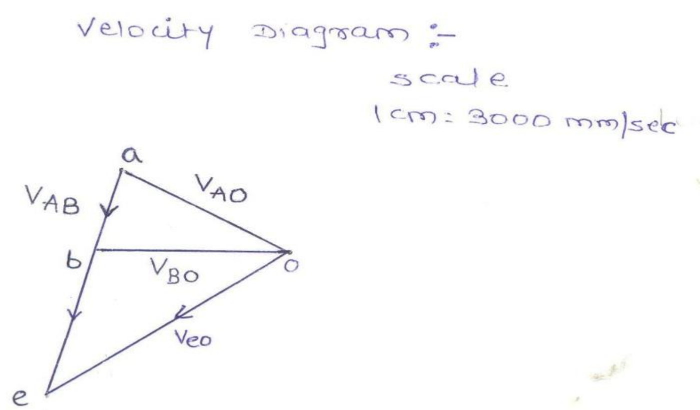
We know that

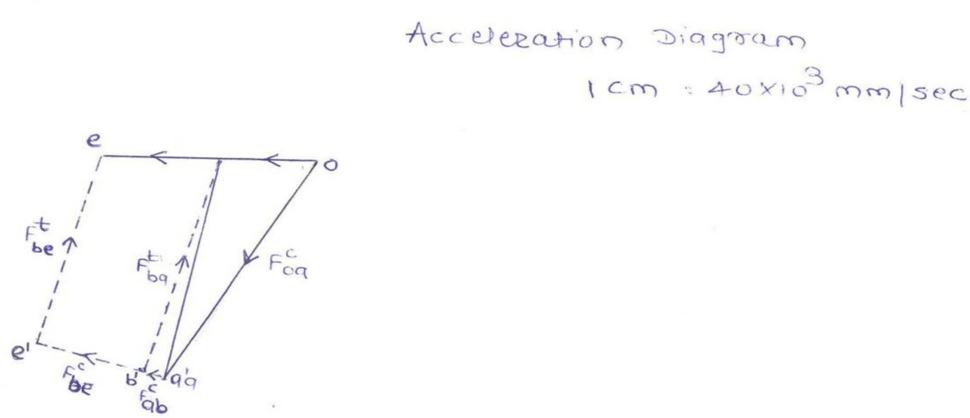
m X r = R

m = $\frac{293.70}{75}$ = 3.91 kg ……**counterbalance** mass [2 M]

Q5A) (velocity diagram with calculation 03+ acceleration diagram 3+ calculations 02)







Calculations:

i) Velocity of crank AO:

$$V_{AO} = rX\omega = 480X20$$

$$V_{AO} = 9600 \text{mm/sec}$$

Velocity of connectingrod (AB)

$$V_{AB} = l(ab)\ X\ Scale = 1.6\ X3000$$

$$V_{AB} = 4800 \text{mm/sec}$$

Velocity of Slider :

$$V_{BO} = l(bo)\ X\ Scale = 3.2\ X3000$$

$$V_{BO} = 9600 \text{mm/sec}$$

Velocity of Extended link :

$$V_{BE} = l(be)\ X\ Scale = 4.5\ X3000$$

$$V_{BE} = 13500 \text{mm/sec}$$

Now,

Calculations for acceleration Diagram:

$$f^c{}_{OA} = \frac{(\text{velocity of crank}^2)}{\text{length of crank}} = \frac{(9600)^2}{480} = 192X10^3 \text{mm/sec}$$

$$f^c{}_{AB} = \frac{(\text{velocity of rod}^2)}{\text{length of rod}} = \frac{(4800)^2}{1600} = 14.4X10^3 \text{mm/sec}$$

$$f^c{}_{BE} = \frac{(\text{velocity of Extended link}^2)}{\text{length of crank}} = \frac{(13500)^2}{2050} = 88.90X10^3 \text{mm/sec}$$

To be find:

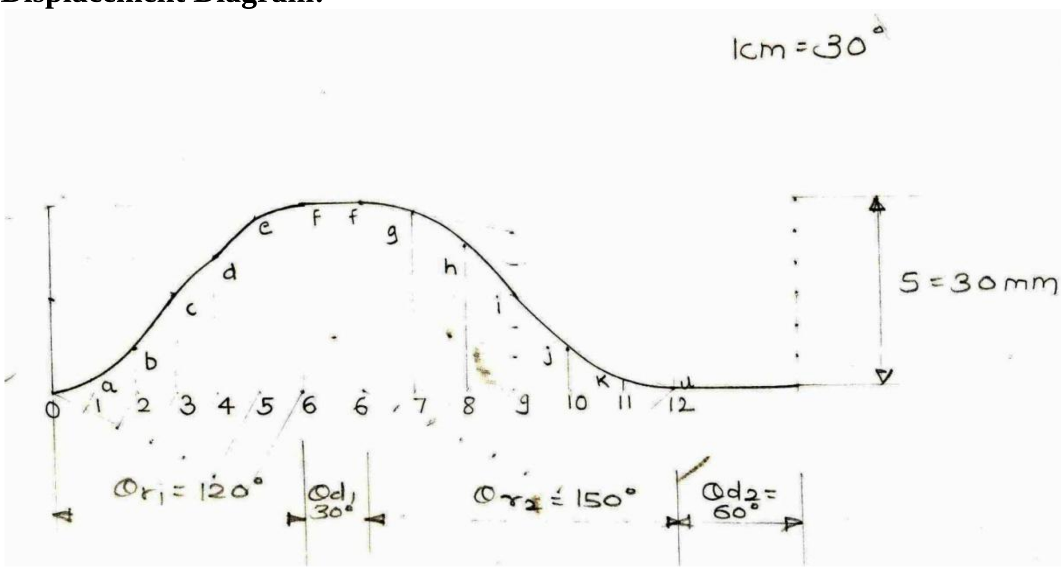
1. **Acceleration of slider:**
   $a_{bo} = l(bo)XScale = 1.6X40X10^3$
   $a_{bo} = 64X10^3 \text{mm/sec}^2$
2. **The Acceleration of point E:**
   $a_{oe} = l(oe)XScale = 3.4X40X10^3$
   $a_{oe} = 136X10^3 \text{mm/sec}^2$
3. **Acceleration of link AB:**

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

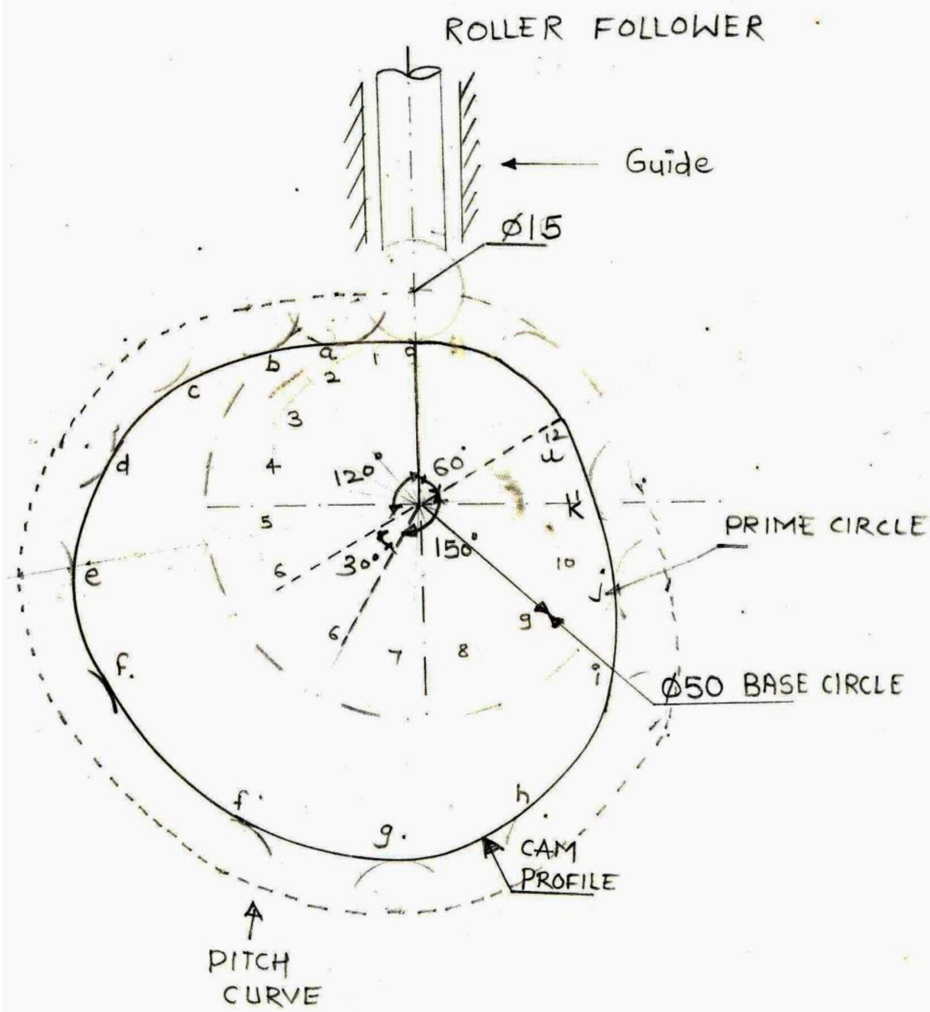
$$a_{ab} = 172 X 10^3 mm/sec^2$$

Q5 b.) **(Displacement diagram 03 mark+ cam profile with labeling 05 marks)**

i) Displacement Diagram:



ii) cam profile:



Q5 c) Given data,

$$D_1 = 480mm = 0.48m \qquad R_1 = 0.24m$$
$$D_2 = 640mm = 0.64m \qquad R_2 = 0.32m$$
$$x = 3m$$

Crossed belt=

$$L = \Pi(r_1 + r_2) + 2x + \frac{(r_1 + r_2)^2}{l}$$ **-------------------------------------1 mark**

$$L = \Pi(0.24 + 0.32) + 2(3) + \frac{(0.24 + 0.32)^2}{3}$$

$$L = 7.863mm$$ **---2 marks**

Now Rotation Alter(open belt)

$L = \Pi(r_1 + r_2) + 2x + \frac{(r_1 - r_2)^2}{l}$ ------------------------------------**1 mark**

$L = \Pi(0.24 + 0.32) + 2(3) + \frac{(0.24 - 0.32)^2}{3}$

$L = 7.76mm$ --**2 marks**

Length of belt should be changed,

L=(Length of cross belt)-(length of open belt)
=7.863-7.76
L=0.103 mm --**2 marks**

Q6A) Slip of Belt:-

Ans:- When driver pulley rotates firm grip between its surface and the belt. This firm grip between pulley and belt is because of friction and known as frictional grip. If this frictional grip becomes insufficient to transmit the motion of pulley to belt. Then there will be.

1) Forward motion of driver pulley without carrying belt called as slip on driving side.
2) Some forward motion of belt without carrying driven pulley this is called as slip on driver side.

The difference between linear speed of rim of pulley and belt on the pulley is known as slip of belt.

The velocity ratio considering slip is given by:-

a) Neglecting Thickness of Belt and Considering Slip:-

$$\frac{N_2}{N_1} - \frac{d_1}{d_2}\left[1 - \frac{5}{100}\right]$$

b) Considering Thickness:-

$$\frac{N_2}{N_1} - \frac{d_1 + t}{d_2 + t}\left[1 - \frac{5}{100}\right]$$

Creep of Belt:-

The belt moves from driving pulley is known as Tight side and belt moves from driving pulley to driver pulley as slack side.

Tension on both i.e. on tight sides and slack side is not equal $(T_1 \rangle T_2)$. The belt material is elastic material which elongates more on Tight side than the slack side resulting in unequal stretching on both sides of drive.

A certain portion of belt when passes from slack side to tight side extends and certain portion of belt when contracts, passes from tight side to slack side because of relative motion.

The relative motion between belt and pulley surface due to unequal stretching of two sides of drives is known as creep.

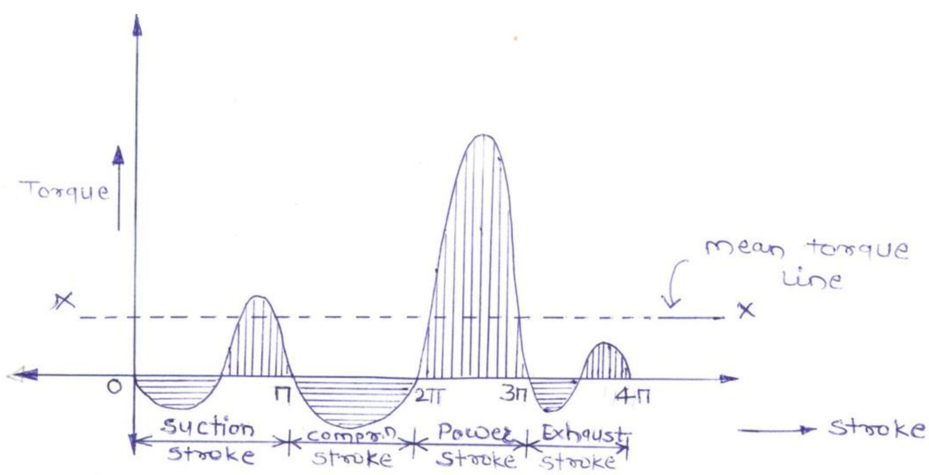
(Slip of belt 02 marks +creep of belt 02 marks)

ii) Single cylinder 4 – stroke I. C. Engine using Turning moment Diagram.

Ans; (Sketch 02+explanation 02)

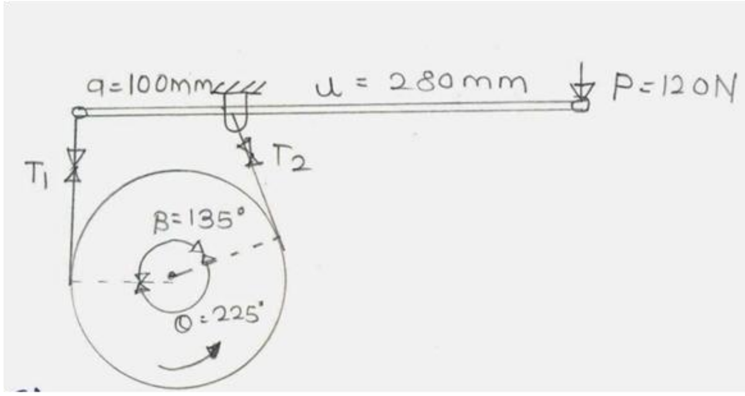
A turning moment diagram for a four stroke cycle internal combustion engine, we know that in a four stroke cycle internal combustion engine, there is one working stroke after a crank has turned through two revolution i.e.720^0.

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.

Q6b) A simple band brake drum:



Sol Given:- **P = 120 N**

N = 200 rpm a = 100 mm = 0.1m

D = 200 mm = 0.2m l = 280 mm = 0.28m

θ = 225^0= 3.92 rad μ = 0.25

K = 0.3m

Ans:-

$$\frac{T_1}{T_2} = e^{\mu\theta} \quad \frac{T_1}{T_2} = e^{(0.25)(3.92)} \quad \frac{T_1}{T_2} = 2.669$$ **-----------------01 mark**

$$P = \frac{T_2 \text{ X } x}{u} = 120 = \frac{T_2 \text{ X } 0.1}{0.28}$$

$T_2 = 336$ N **-----------------01 mark**

$T_1 = T_2$ X 2.669

$T_1 = 336$ X 2.669 ; $T_1 = 896.784$ N **-----------------01 mark**

$T_B = (T_1 - T_2)R$ _ $T_B = (896.784 - 336)0.1$

$T_B = 56$ N.m **-----------------01 mark**

1) K. E. of Flywheel:-

$$\frac{1}{2} I\,\omega^2 = \frac{1}{2} \text{ X } (mk^2)\left(\frac{2\,\Pi\,N}{60}\right)^2$$

$$= \frac{1}{2} \text{ X } (250 \text{ X } 0.3^2)\left(\frac{2 \text{ X } \Pi \text{ X } 200}{60}\right)^2$$

$= \frac{1}{2} \text{ X } 22.5 \text{ X } 438.64$; K. E. = 4934.80 N. m--------------------**02 mark**

Let n = Number of revolution before it comes to rest

Work done = $T_b \text{ X } \theta = T_b \text{ X } 2 \text{ X } \Pi \text{ X } n$

$= 56.07 \text{ X } 2 \text{ X } \Pi \text{ X } n$

$= (352.298 \text{ X } n) \text{ N.m}$ **---------1 mark**

Work done = change in K. E.

$n = \frac{4934.80}{352.298}$; $n = 14.007$ **--------------------1 mark**

Q6c) Given data,

$2\alpha = 100^0$ $\alpha = 50^0$

$W = 18 \text{ KN}$ $P_{max} = 300 \text{ X } 10^3 \text{ N/m}^2$

$\mu = 0.05$ $N = 150 \text{ rpm}$

$R_1 = 2.5 R_2$

Ans:- $W = P \text{ X } \Pi (R_1^2 - R_2^3)$ **------------------------1 mark**

$18 \text{ X } 10^3 = 300 \text{ X } 10^3 (3.142)((2.5R_2)^2 - (R_2)^2$

$0.019 = 1.5 R_2^2$

$R_2 = 0.11 \text{ m}$ **------------------1 mark**

$R_1 = 2.5 \text{ X } 0.11$; $R_1 = 0.281 \text{m}$ **------------------1 mark**

$\therefore T = \frac{2}{3} \mu W \frac{(R_1^3 - R_2^3)}{(R_1^2 - R_2^2)\sin\alpha}$ **------------------2 marks**

$$\therefore T = \frac{2}{3} \frac{0.05 \text{ X } 18 \text{ X } 10^3((0.281)^3 - (0.11)^3)}{((0.281)^2 - (0.11)^2)\sin 50^0}$$

$$T = \frac{16.336}{((0.281)^2 - (0.11)^2)}$$

$T = 244.33 \text{ N.m}$ **------------------1 mark**

$$P = \frac{2 \Pi N T}{60} = \frac{2 \text{ X } \Pi \text{ X } 150 \text{ X } 244.33}{60} = 3.837 \text{ X } 10^3 \text{ Watt} = 3.837 \text{ K Watt}$$

Power Lost = 3.837 KW------------------2 marks