SUMMER– 15 EXAMINATION

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 and 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. (02 marks each)

a) Each part of a machine, which moves relative to some other part, is known as a **kinematic link.**

When the kinematic pairs are coupled in such a way that the last link is joined to the first link to transmit definite motion (i.e. completely or successfully constrained motion), it is called a **kinematic chain**.

b) **Motion of the Follower**

1. Uniform velocity, 2. Simple harmonic motion,

3. Uniform acceleration and retardation, and 4. Cycloidal motion.

c) **Slip of belt:** The motion of belts and shafts assuming a firm frictional grip between the belts and the shafts. But sometimes, the frictional grip becomes insufficient. This may cause some forward motion of the driver without carrying the belt with it. This may also cause some forward motion of the belt without carrying the driven pulley with it. This is called slip of the belt and is generally expressed as a percentage.

Angle of Lap: The angle of lap is defined as the angle subtended by the portion of the belt which is in contact at the pulley surface of the pulley.

d) **Conditions for 'V' Belt drive selection:**

1. Great amount of Power to be transmitted,
2. Requirement of the high velocity ratio (maximum 10).
3. Small Centre distance between the shafts
4. Positive drive requirement
5. Compact Space

e) **The function of a governor** is to regulate the mean speed of an engine, when there are variations in the load e.g. when the load on an engine increases, its speed decreases, therefore it becomes necessary to increase the supply of working fluid. On the other hand, when the load on the engine decreases, its speed increases and thus less working fluid is required. The governor automatically controls the supply of working fluid to the engine with the varying load conditions and keeps the mean speed within certain limits.

f) **Applications of flywheel**: Used in Internal combustion engines, press machines, mills, punching machines.

g) **Function of dynamometer:**

A dynamometer is a brake but in addition it has a device to measure the frictional resistance. Knowing the frictional resistance, we may obtain the torque transmitted and hence the power of the engine.

Absorption type dynamometers:

1. Prony brake dynamometer, and 2. Rope brake dynamometer.

Transmission type dynamometers

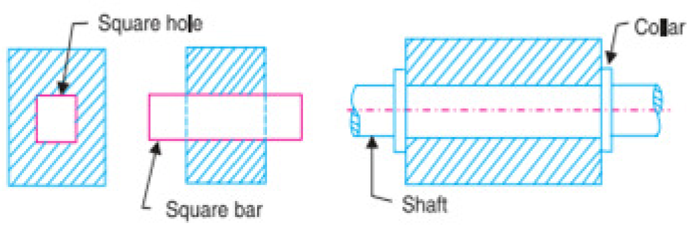
1. Epicyclic-train dynamometer, 2. Belt transmission dynamometer, and 3. Torsion dynamometer.

h) **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.

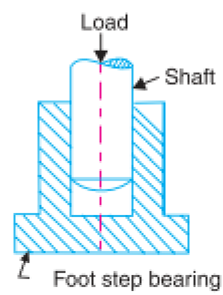
These forces not only increase the loads on bearings and stresses in the various members, but also produce unpleasant and even dangerous vibrations. The balancing of unbalanced forces is caused by rotating masses, in order to minimize pressure on the main bearings when an engine is running.

Q1 (B) a) (02 marks for definition + 02 marks for fig)

Completely constrained motion. When the motion between a pair is limited to a definite direction irrespective of the direction of force applied, then the motion is said to be a completely constrained motion. For example, the piston and cylinder (in a steam engine) form a pair and the motion of the piston is limited to a definite direction (i.e. it will only reciprocate) relative to the cylinder irrespective of the direction of motion of the crank, e.g. Square bar in a square hole. & Shaft with collars in a circular hole.



Completely constrained motion.



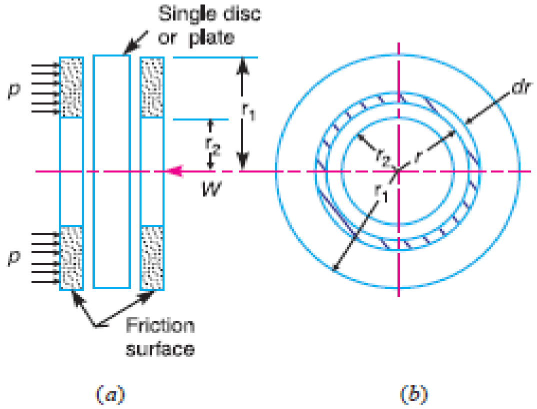
Successfully constrained motion

Successfully constrained motion. When the motion between the elements, forming a pair, is such that the constrained motion is not completed by itself, but by some other means, then the motion is said to be successfully constrained motion. Consider a shaft in a foot-step bearing as shown in Fig. The shaft may rotate in a bearing or it may move upwards. This is a case of incompletely constrained motion. But if the load is placed on the shaft to prevent axial upward movement of the shaft, then the motion of the pair is said to be successfully constrained motion. The motion of an I.C. engine valve (these are kept on their seat by a spring) and the piston reciprocating inside an engine cylinder are also the examples of successfully constrained motion.

b) Working Principle of Clutch and its location in an automobile:
(02 marks for Principle, 01 for Fig, 01 for Location)

A friction clutch has its principal application in the transmission of power of shafts and machines, which must be started and stopped frequently. The force of friction is used to start the driven shaft from rest and gradually brings it up to the proper speed without excessive slipping of the friction surfaces. In automobiles, friction clutch is used to connect the engine to the driven shaft. In operating such a clutch, care should be taken so that the friction surfaces engage easily and gradually brings the driven shaft up to proper speed.

Location: Between the engine and gear box.



single disc or plate clutch.

A single disc or plate clutch, as shown in Fig. consists of a clutch plate whose both sides are faced with a friction material (usually of Ferrodo). The pressure plate is mounted inside the clutch body which is bolted to the flywheel. Both the pressure plate and the flywheel rotate with the engine crankshaft or the driving shaft. The pressure plate pushes the clutch plate towards the flywheel by a set of strong springs which are arranged radially inside the body. When the clutch pedal is pressed, both the plates gets disengaged and when it is released, both gets engaged. Because of this power is transmitted through friction plate.

c) Comparison between cross belt drive and open belt drive: (01 mark for each point)

Sr. No.	**Parameter**	**Cross belt drive**	**Open belt drive**
1	Velocity ratio	High	Low
2	Application	Large amount of power to be transmitted	Less amount of power to be transmitted
3	Direction of driven pulley	Same as driver pulley	Opposite to driven pulley
4	Length of belt drive	Long	short

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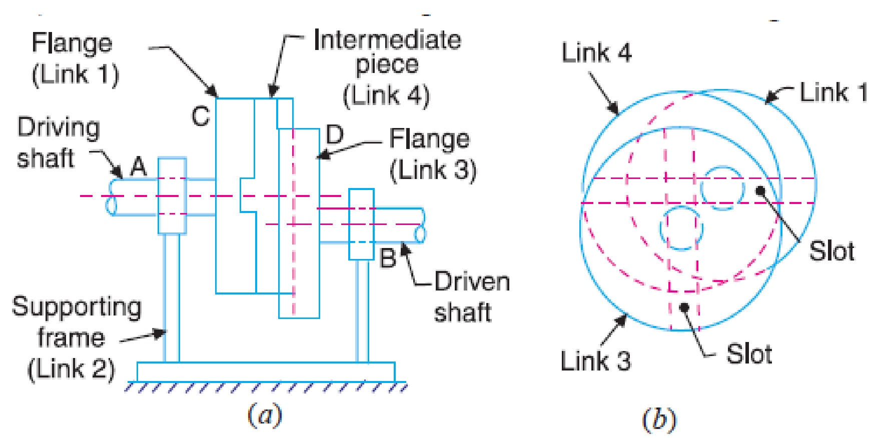
Q2 (a) **Difference (01 mark for each point)**

Sr. No.	Machine	Structure
1	Relative motion exist between its parts	No relative motion exists between its members.
2	Links are meant to transmit motion and forces which are dynamic (both static and kinetic)	Members are meant for carrying loads or subjected to forces having straining actions
3	Machines serve to modify and transmit mechanical work.	Structure serves to modify and transmit forces only.
4	Example: shaper, lathe , screw jack etc	Examples: roof trusses, bridges, buildings, machine frames etc.

(b) Working Principle of Oldham's coupling:

(02 marks for explanation + 02 marks for fig)

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.

(c) (01 mark for each)

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, $\omega = \theta d/dt$

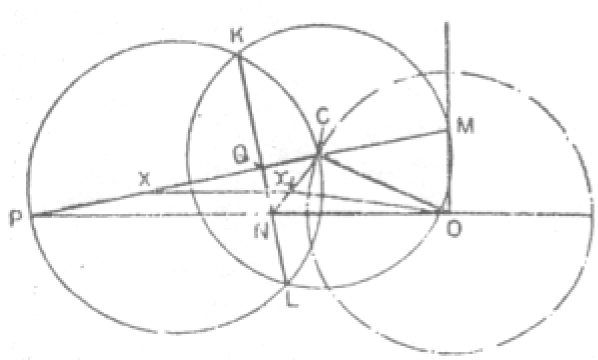
Absolute Velocity It is defined as the velocity of any point on a kinematic link with respect to fixed point.

Relation between v and ω: $V = r. \omega$
Where V = Linear velocity
ω =angular velocity
r = radius of rotation

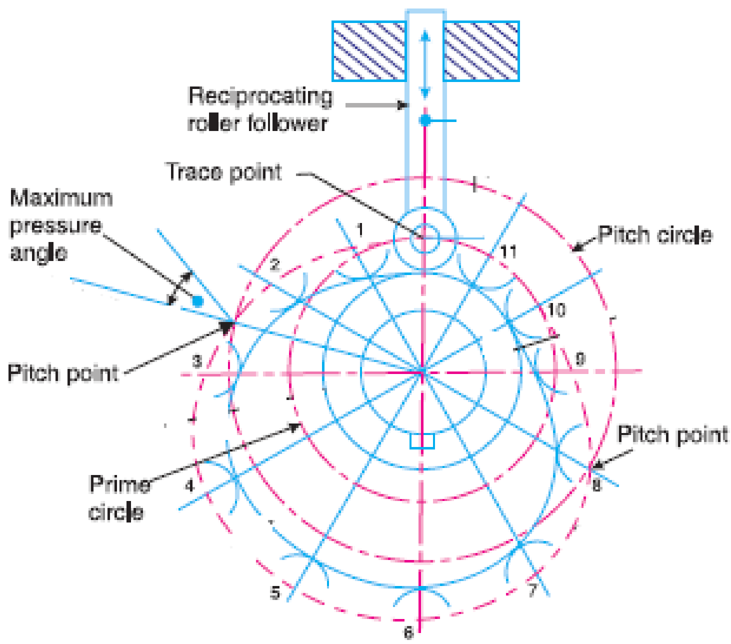
(d) Steps in Klein's construction (04 marks for appropriate answer)

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.



(e) Radial cam with roller follower (04 marks for diagram with names)



f) Problem on belt drive (02 marks each length)

i) for open belt

$$L = \pi/2\,(d_1 + d_2) + 2x + (d_1 - d_2)^2 / 4x$$

$= 9.8865$ m

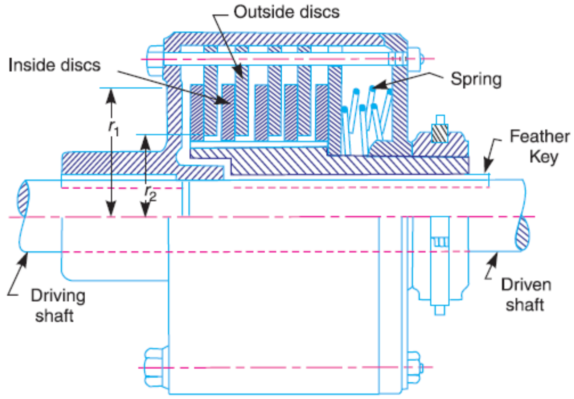
ii) for cross belt

$$L = \pi/2\,(d_1 + d_2) + 2x + (d_1 + d_2)^2 / 4x$$

$= 9.974$ m

Q. 3 Attempt any four

a) Labeled sketch of Multi-plate clutch. (Sketch 2Marks, Labeling 2Marks)



Multiple disc clutch.

b) Why roller follower is preferred over a knife edge follower?
(02 marks for explanation, 01 for adv & 01 for Application)

In case of knife edge follower there is sliding motion between the contacting surface of cam and follower. Because of small contact area, there is excessive wear; therefore it is not frequently used. Whereas in roller follower there is rolling motion between contacting surfacing and more contact area, therefore rate of wear is greatly reduced.

Advantages: **i)** Less wear, more life

ii) Less side thrust as compared to knife edge follower.

Application: Used in stationary oil and gas engines

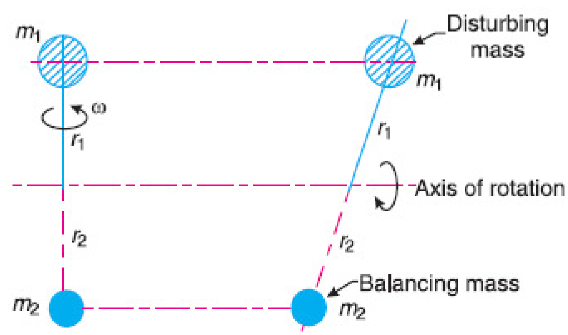
c) **Balancing of single rotating mass by single masses rotating in the same plane**
(03 marks for procedure + 01 mark for fig)

Consider a disturbing mass m_1 attached to a shaft rotating at ω rad/s as shown in Fig. 21.1. Let r_1 be the radius of rotation of the mass m_1 (*i.e.* distance between the axis of rotation of the shaft and the centre of gravity of the mass m_1).

We know that the centrifugal force exerted by the mass m_1 on the shaft,

$$F_{C1} = m_1 \cdot \omega^2 \cdot r_1 \quad \ldots (i)$$

This centrifugal force acts radially outwards and thus produces bending moment on the shaft. In order to counteract the effect of this force, a balancing mass (m_2) may be attached in the same plane of rotation as that of disturbing mass (m_1) such that the centrifugal forces due to the two masses are equal and opposite.



Balancing of a single rotating mass by a single mass rotating in the same plane.

Let r_2 = Radius of rotation of the balancing mass m_2 (*i.e.* distance between the axis of rotation of the shaft and the centre of gravity of mass m_2).

$\therefore$ Centrifugal force due to mass m_2,

$$F_{C2} = m_2 \cdot \omega^2 \cdot r_2 \quad \ldots (ii)$$

Equating equations (*i*) and (*ii*),

$$m_1 . \omega^2 \cdot r_1 = m_2 \cdot \omega^2 \cdot r_2 \quad \text{or} \quad m_1 \cdot r_1 = m_2 \cdot r_2$$

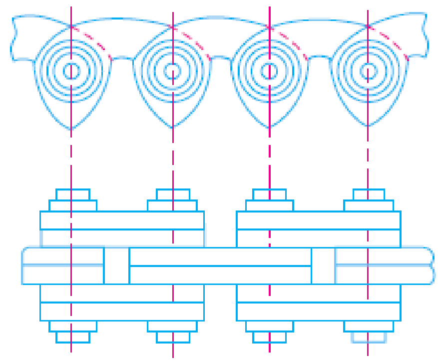
d) **Types of power transmission chains: (Types 1M, sketch 1M, explain 2 M)**

i) Block chain or bush chain drive

ii) Bush roller chain

iii) Inverted tooth or silent chain

Fig. shows inverted tooth or silent chain. It is designed to eliminate the evil effects caused by stretching and to produce noiseless running. When the chain stretches and the pitch of the chain increases, the links ride on the teeth of the sprocket wheel at a slightly increased radius. This automatically corrects the small change in the pitch. There is no relative sliding between the teeth of the inverted tooth chain and the sprocket wheel teeth. When properly lubricated, this chain gives durable service and runs very smoothly and quietly.

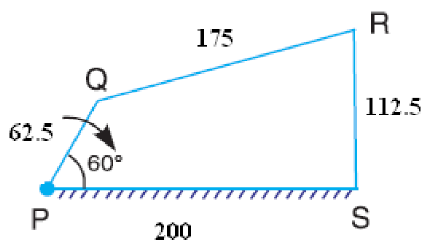


Inverted tooth or silent chain.

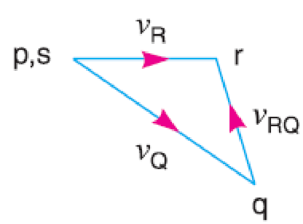
e) **PQRS four bar chain** with PS fixed, PQ = 62.5, QR = 175, RS = 112.5, PS = 200 mm, ω_{pq} = 10 rad / sec, ω_R = ? **(Diagram 1Mark, Ans 3Marks)**

(Note: Following diagrams are not to scale.)

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

$$\text{vector } pq = V_{qp} = V_q = 0.625 \text{ m/s}$$

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

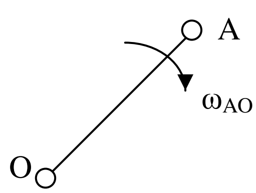
$$V_{rs} = V_r = \text{vector } sr = 0.43 \text{ m/s}$$

We know that $RS = 112.5 \text{ mm} = 0.1125 \text{ m}$

∴ Angular velocity of R = Ang. Velo. of link RS (clockwise about S)

$$\omega_{RS} = \frac{V_{rs}}{RS} = \frac{0.43}{0.1125} = 3.82 \text{ rad/s} \quad \textbf{Ans.}$$

f) Crank OA of a mechanism is hinged at O. **(Fig 1Mark)**



$\omega_{AO} = 20$ rad/s and $\alpha_{AO} = 20$ rad/s^2

Angular velocity $\omega_{AO} = 20$ rad /sec, $\alpha_{AO} = 20$ rad /s^2 , OA = 50 mm

Linear velocity $V_{AO} = \omega_{AO} \times OA = 20 \times 50/1000 = 1$ m/s **(1 Mark)**

Centripetal acceleration = $a^r_{AO} = a_B = \omega^2_{AO} \times OA = 20 \times 20 \times 0.05 = 20$ m/s^2 **(1 Mark)**

Tangential acceleration = $\alpha^t_{OA} = a^t_{AO} / OA$

$a^t_{AO} = OA \times \alpha^t_{OA} = 0.05 \times 20 = 1$ rad / s^2 **(1 Mark)**

Q. 4 Attempt any four

a) **Concept of slip and creep in the belt drive**

Slip of the belt: **(Concept 1M, effect 1M)**

A firm frictional grip between belt and shaft is essential. But sometimes it becomes insufficient. This may cause some forward motion of the belt without carrying the driven pulley with it. This called as slip of the belt. It is expressed as a percentage.

Effect on velocity ratio: Result of belt slipping is to reduce the velocity ratio of the system.

Creep in belt drive: **(Concept 1M, effect 1M)**

When the belt passes from slack side to tight side, a certain portion of the belt extends and it contracts again when the belt passes from tight sight to slack side. Due to these changes in length, there is a relative motion between the belt and the pulley surfaces. This relative motion is called as creep.

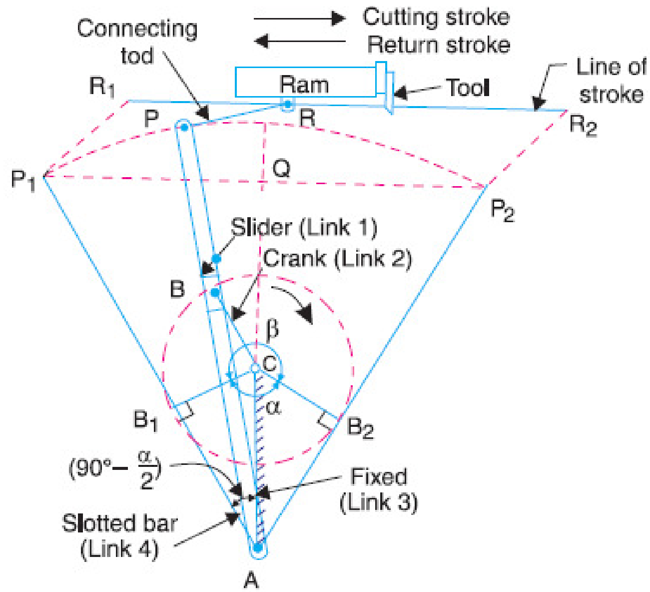
Effect on velocity ratio: The total effect of creep is to reduce slightly the speed of the driven pulley or follower.

b) **Working of crank and slotted lever quick return mechanism**.

(02 M sketch, 02 M for description)

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, $AP1$ and $AP2$ 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 $CB1$ to $CB2$ (or through an angle β) in the clockwise direction. The return stroke occurs when the crank rotates from the position $CB2$ to $CB1$ (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

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

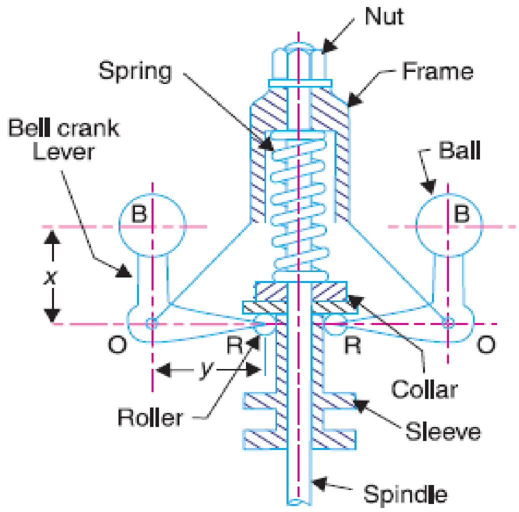
$$= 2AP_1 \sin\left(90^\circ - \frac{\alpha}{2}\right) = 2AP \cos\frac{\alpha}{2} \qquad \text{..... } (\because AP_1 = AP)$$

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

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

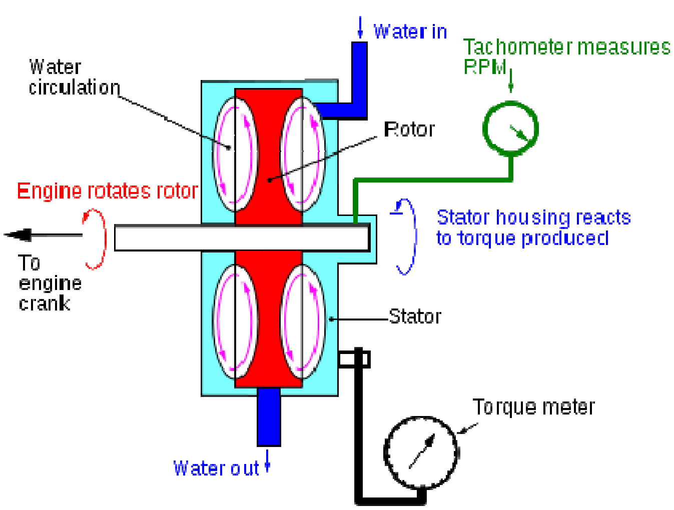
c) Hartnell governor: (Sketch 2M, explanation 2 M)

A Hartnell governor is a spring loaded governor as shown in Fig. 18.18. It consists of two bell crank levers pivoted at the points O,O to the frame. The frame is attached to the governor spindle and therefore rotates with it. Each lever carries a ball at the end of the vertical arm OB and a roller at the end of the horizontal arm OR. A helical spring in compression provides equal downward forces on the two rollers through a collar on the sleeve. The spring force may be adjusted by screwing a nut up or down on the sleeve.



Hartnell governor.

d) Hydraulic Dynamometer: (Sketch 2M, explanation 2 M)



Hydraulic dynamometer is also called as water brake absorber. Invented by British engineer William Froude in 1877 in response to a request by the Admiralty to produce a machine capable of absorbing and measuring the power of large naval engines, water brake absorbers are relatively common today.
The schematic shows the most common type of water brake, known as the "variable level" type. Water is added until the engine is held at a steady RPM against the load, with the water then kept at that level and replaced by constant draining and refilling (which is needed to carry away the heat created by absorbing the horsepower). The housing

attempts to rotate in response to the torque produced, but are restrained by the scale or torque metering cell that measures the torque.

e) Balancing mass m = ? (01 mark each for ΣH, ΣV, R & θ)

Given : m_1 = 10 kg ; m_2 = 20 kg ; m_3 = 15 kg ;

$r_1 = 0.2$ m ; $r_2 = 0.25$ m; $r_3 = 0.15$ m; $r = 0.30$m

$\theta_1 = 0°$; $\theta_2 = 60°$; $\theta_3 = 150°$

Let m = Balancing mass, and

θ = The angle which the balancing mass makes

Since the magnitude of centrifugal forces are proportional to the product of each mass and its radius,

therefore

$m_1 \cdot r_1 = 10 \times 0.2 = 2$ kg-m

$m_2 \cdot r_2 = 20 \times 0.25 = 5$ kg-m

$m_3 \cdot r_3 = 15 \times 0.15 = 2.25$ kg-m

Resolving $m_1.r_1$, $m_2.r_2$, $m_3.r_3$ and $m_4.r_4$ horizontally,

$$\Sigma H = m_1 \cdot r_1 \cos\theta_1 + m_2 \cdot r_2 \cos\theta_2 + m_3 \cdot r_3 \cos\theta_3$$

$$= 2 \cos 0° + 5 \cos 60° + 2.25 \cos 150°$$

$$= \boxed{2.55 \text{ kg-m}}$$

Now resolving vertically,

$$\Sigma V = m_1 \cdot r_1 \sin\theta_1 + m_2 \cdot r_2 \sin\theta_2 + m_3 \cdot r_3 \sin\theta_3$$

$$= 2 \sin 0° + 5 \sin 60° + 2.25 \sin 150°$$

$$= \boxed{5.455 \text{ kg-m}}$$

$\therefore$ Resultant, $R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \boxed{6.02 \text{ kg-m}}$

We know that

$m \cdot r = R = 6.02$ m = 6.02 / 0.30 = 20.067 kg

and $\tan\theta' = \Sigma V / \Sigma H$ = $\boxed{\theta' = 64.94°}$

f) (02 marks for each answer)

N =6, d_1 =600 mm, r1 =300 mm, d2 =300 mm, r2 =150 mm, W =100 kN =100 x 10^3 N μ = 0.12, N = 90 rpm, ω = 2 x π x N /60 = 2 x π x 90/ 60 =9.426 rad / sec

1. Power absorbed in friction, assuming uniform pressure

We know that total frictional torque transmitted,

$$T = \frac{2}{3} \times \mu . W \left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2} \right]$$

$$= \frac{2}{3} \times 0.12 \times 100 \times 10^3 \left[\frac{(300)^3 - (150)^3}{(300)^2 - (150)^2} \right] = 2800 \times 10^3 \text{ N-mm}$$

$$= 2800 \text{ N-m}$$

∴ Power absorbed in friction,

$$P = T.\omega = 2800 \times 9.426 = 26\,400 \text{ W} = 26.4 \text{ kW} \textbf{ Ans.}$$

2. Power absorbed in friction assuming uniform wear

We know that total frictional torque transmitted,

$$T = \frac{1}{2} \times \mu . W (r_1 + r_2) = \frac{1}{2} \times 0.12 \times 100 \times 10^3 \ (300 + 150) \text{ N-mm}$$

$$= 2700 \times 10^3 \text{ N-mm} = 2700 \text{ N-m}$$

∴ Power absorbed in friction,

$$P = T.\omega = 2700 \times 9.426 = 25\,450 \text{ W} = 25.45 \text{ kW} \textbf{ Ans.}$$

Q 5 a) Solution of problem on Reciprocating Engine (02 Marks of each term finding)

Given : r= 250 mm = 0.25 m , l= 1000 mm = 1 m , θ = 30°; N = 150 rpm

ω = π × 150 / 60 = 7.85 rad/s

1. Velocity of piston

We know that ratio of the length of connecting rod and crank,

$$n = l / r = 1 / 0.25 = 4$$

∴ Velocity of the slider,

$$v_P = \omega . r\left(\sin\theta + \frac{\sin 2\theta}{2n}\right) = 7.85 \times 0.25\left(\sin 30 + \frac{\sin 60^\circ}{2 \times 4}\right) \text{m/s}$$

$= 1.19$ m/s **Ans.**

Q 5 b)

and acceleration of the slider,

$$a_P = \omega^2 . r\left(\cos\theta + \frac{\cos 2\theta}{n}\right) = (7.85)^2 \times 0.25\left(\cos 30^\circ + \frac{\cos 60^\circ}{4}\right) \text{m/s}^2$$

$= 15.27$ m/s² **Ans.**

2. Angular velocity & Angular acceleration of Con Rod

We know that angular velocity of the connecting rod,

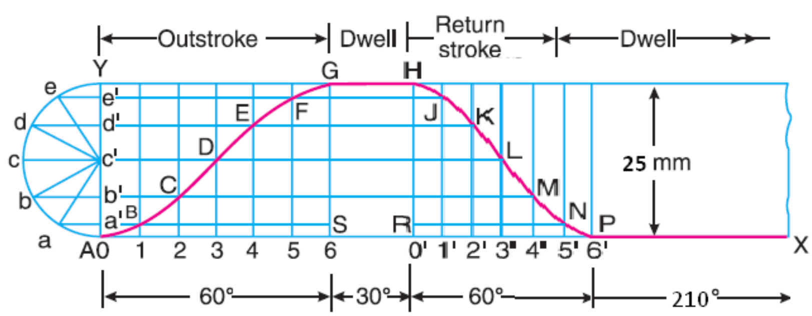
$$\omega_{PC} = \frac{\omega\cos\theta}{n} = \frac{7.85 \times \cos 30^\circ}{4} = 1.67 \text{ rad/s} \quad \textbf{Ans.}$$

and angular acceleration of the connecting rod,

$$\alpha_{PC} = \frac{\omega^2 \sin\theta}{n} = \frac{(7.85)^2 \times \sin 30^\circ}{4} = 7.7 \text{ rad/s}^2 \quad \textbf{Ans.}$$

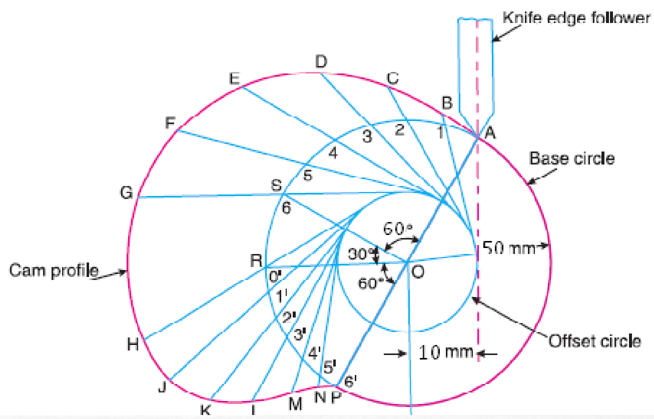
Displacement Diagram & Cam Profile

(03 Marks for Dis. Dig + 05 Marks for cam Profile)



Displacement Diagram

Note: In solution cam profile angles are not taken by measurement. In actual drawing in answer books it should be drawn by measurements only)



5 c)

$P = 10 \times 10^3$ W, $N_1 = 600$ rpm, $d_1 = 250$ mm $= 0.25$ m

$\mu = 0.25$, $x = 1.25$ m, $\rho = 0.001$ gm/mm³

$\sigma = 2.5$ N/mm², $N_2 = 200$ rpm

$$\frac{N_1}{N_2} = \frac{d_2}{d_1} \quad \therefore d_2 = 0.75 \text{ m}$$

$$\therefore r_2 = 0.375 \text{ m}$$

We have,

$$\sin\alpha = \frac{r_2 - r_1}{x} = \frac{0.375 - 0.125}{1.25}$$

$$\therefore \alpha = 11.53°$$

$$\therefore 2\alpha = 23.07°$$

$$\therefore \text{Angle of lap } \theta = 180 - 2\alpha$$

$$= 156.9°$$

$$= 2.73 \text{ rad}$$

Velocity $v = \frac{\pi d_1 N_1}{60} = 7.85$ m/sec

Power $P = (T_1 - T_2) \cdot v$

$$\therefore T_1 - T_2 = 1273.90 \text{ ----} (1)$$

Also, $\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.25 \times 2.73} = 1.97$ --- (2)

from eqn (1) & (2) $T_1 = 1313.3$ N &

$T_2 = 667$ N

Now, $T_1 = \sigma \times b \times t = 2.5 \times b \times 12$

$$\therefore b = 43.77 \text{ mm}$$

Note:- If prob is solved considering m & T_c, give full credit

Problem on Belt (02 marks for α , 02 for θ, 02 for T_1 & T_2 and 02 for Width)

Q 6 a i) Gear Train, Purpose & types (01 mark each for definition & purpose, 02 marks for types)

Definition: When two or more gears are made to mesh with each other to transmit power from one shaft to another. Such a combination is called ***gear train***

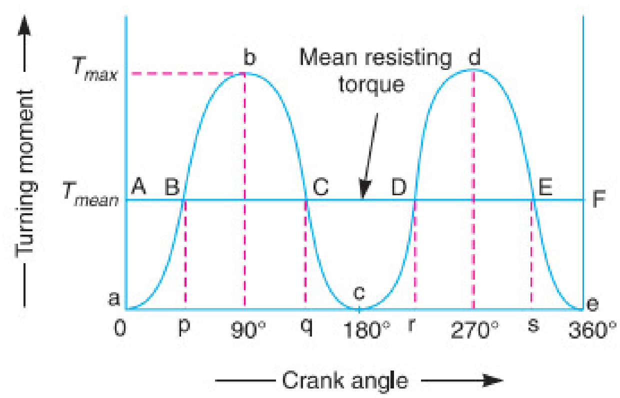
Purpose: The purpose of the train used is
To obtain correct & required velocity ratio between driver & driven shafts
To decide upon the relative position of the axes of shafts.
To decide upon amount of power to be transmitted between shafts

Types: Following are the different types of gear trains, depending upon the arrangement of wheels :

1. Simple gear train,
2. Compound gear train,
3. Reverted gear train, and
4. Epicyclic gear train.

Q6 a ii) Concept of fluctuation energy w.r.t. turning moment diagram
(02 marks for diagram & 02 for explanation)

Fluctuation of energy: It is the difference between the maximum and minimum energy of Flywheel.



Consider the turning moment diagram for a single cylinder double acting steam engine as shown in Fig. on X axis crank angle is taken We see that the mean resisting torque line *AF* cuts the turning moment diagram at points *B*, *C*, *D* and *E*. The variations of energy above and below the mean resisting torque line are called ***fluctuations of energy***. The areas *BbC*, *CcD*, *DdE*, etc. represent fluctuations of energy. More fluctuation of energy of energy indicates more variation in the speed and so, bigger requirement of a flywheel.

SUMMER– 15 EXAMINATION

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

Q6 b) Problem on simple band brake (01 mark for Θ, 03 for T_1 & T_2 , 04 for T_B)

$d = 0.4\,m$, $r = 0.2\,m$, $l = 0.4\,m$, $\mu = 0.25$

$\theta = \frac{5}{8} \times 360° = 225° = 3.92\,rad$, $b = 0.08\,m$.

We have,

$$\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.25 \times 3.92} = 2.66 \text{ ----- (1)}$$

Braking Torque

$T_B = (T_1 - T_2) \times r$

Taking moments about

$P \times l = T_2 \times b$

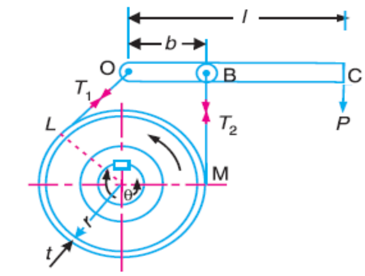
$500 \times 0.4 = T_2 \times 0.08$

$\therefore T_2 = 2500\,N$

& $T_1 = 6650\,N$

So, $T_B = (6650 - 2500) \times 0.2$

$= 830\,N\text{-}m$



Anticlockwise rotation of drum.

Q6 c) Problem on single plate clutch (01 mark for R, 03 for r_1 & r_2 , 04 for force W)
(Note: Calculated values of r_1 , r_2 & W are not practical with given data)

Max. Torque $T = 147\,N\text{-}m$, $n = 2$

$d_1 = 1.2\,d_2$, $\mu = 0.3$, $P_{max} = 98 \times 10^3\,N/m^2$

uniform wear condition

Mean rad. $R = \frac{r_1 + r_2}{2} = \frac{1.2\,r_2 + r_2}{2}$

$= 1.1\,r_2$

$T = n\mu W R = 2 \times 0.3 \times W \times 1.1\,r_2$

$\therefore W = 222.7\,r_2$ ------- (1)

Also, $p \cdot r_2 = C$ $\therefore C = 98 \times 10^3\,r_2$ ---- (2)

But $W = 2\pi C(r_1 - r_2)$

$222.7\,r_2 = 2\pi \times 98 \times 10^3\,r_2(1.2\,r_2 - r_2)$

$222.7 = 123088\,r_2$

$\therefore r_2 = 1.8\,mm$

& $r_1 = 1.2 \times 1.8 = 2.1\,mm$

$W = 222.7 \times 1.8 \times 10^{-3}$

$= 0.40\,N$