MODEL ANSWER

SUMMER– 17 EXAMINATION

Subject Title: MECHANICAL ENGG.DRAWING Subject Code: 17412

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. No.	Sub Q. N.	Answer	Marking Scheme
Q No. 1		Answer any TEN of the following	
	a)	**Inversion of Mechanism** **W**hen one of the links is fixed in a kinematic chain, it is called a mechanism. So we can obtain as many mechanisms as the number of links in a kinematic chain by fixing, in turn, different links in a kinematic chain. This method of obtaining different mechanisms by fixing different links in a kinematic chain is known as inversion of the mechanism.	02
	b)	**Inversions of Double Slider Crank Chain** 1. Elliptical trammels. 2. Scotch yoke mechanism. 3. Oldham's coupling.	02
	c)	**Sliding pair** When the two elements of a pair are connected in such a way that one can only slide relative to the other, the pair is known as a sliding pair. The piston and cylinder, cross-head and guides of a reciprocating steam engine, ram and its guides in shaper, tail stock on the lathe bed etc. are the examples of a sliding pair. A little consideration will show that a sliding pair has a completely constrained motion.	02

d) **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. 02

e) **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

f) **Classification of cam:**

1. Radial or disc cam.

In radial cams, the follower reciprocates or oscillates in a direction perpendicular to the cam axis. The cams as shown in above Fig. are all radial cams. 02

2. Cylindrical cam.

In cylindrical cams, the follower reciprocates or oscillates in a direction parallel to the cam axis. The follower rides in a groove at its cylindrical surface. A cylindrical grooved cam with a reciprocating and an oscillating follower is shown in Fig. below (a) and (b) respectively.

g) **Define the following terms:** 02

i. Prime circle. It is the smallest circle that can be drawn from the centre of the cam and tangent to the pitch curve. For a knife edge and a flat face follower, the prime circle and the base circle are identical. For a roller follower, the prime circle is larger than the base circle by the radius of the roller.

ii. Pitch circle. It is a circle drawn from the centre of the cam through the pitch points.

iii. 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 angle is too large, a reciprocating follower will jam in its bearings. 02

iv. Trace point. It is a reference point on the follower and is used to generate the pitch curve. In case of knife edge follower, the knife edge represents the trace point and the pitch curve corresponds to the cam profile. In a roller follower, the centre of the roller represents the trace point.

h) **Limitations of knife edge follower** are 02

1. Excessive wear due to small area of contact between cam & follower surfaces.

		2. In this follower a considerable thrust exists between the follower and guide.	
	i)	**Methods to reduce the slip in belt and pulley:** 1. Vertical belt drive should be avoided. 2. In horizontal belt drive the upper side should be kept as loose side.	02
	j)	**Formula for length of open belt drive and cross belt drive:** Open belt drive: $L = 2C + \pi(D_2 + D_1)/2 + (D_2 - D_1)^2/4C$ Cross belt drive: $L = 2C + \pi(D_2 + D_1)/2 + (D_2 + D_1)^2/4C$ Where L=length. C=centre distance. D1 = pitch diameter of small pulley. D2 =pitch diameter of large pulley.	02
	k)	**Law of Gearing:** The law of gearing states that the angular velocity ratio of all gears of a meshed gear system must remain constant also the common normal at the point of contact must pass through the pitch point.	02
	l)	**Self energizing & Self Locking brake** Rn x X = PL + μaRn Rn = Normal reaction, P = Applied force, L = lever length X = Distance of block from hinge, μ= coefficient of friction, a = distance of drum from hinge In the above equation when frictional force adds to the breaking torque. In other words, the frictional torque and braking torque are in the same direction its a self locking brake. In the above equation when X < μa, P becomes negative Hence, P is not required for braking and brake gets applied on its own. It is called as self energizing brake.	02

m) **Limitations of a shoe brake**

1. Heavy side thrust causes bending of the shaft. 02
2. More wear & tear as the contact surface is large.

n) **Uniform Wear theory**

When the product of pressure and area of the contacting surface transmitting load is taken as constant to determine the axial force & torque, it is termed as uniform wear theory as it is assumed that wear along the surface is uniform. 02

Uniform pressure theory

When the pressure applied on the contacting surface transmitting load is taken as constant to determine the axial force & torque, it is termed as uniform pressure theory as it is assumed that clutch is new.

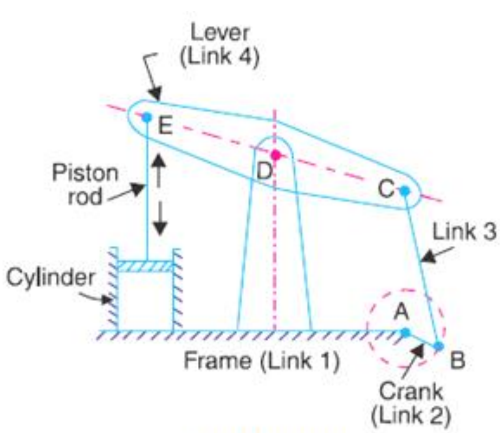
o) **Effects of imbalance in machine**

1. Imbalance imparts vibratory motion to the frame of the machine.
2. Produces noise which leads to human discomfort. 02
3. Detrimental effects on the machine performance & structural integrity of the machine foundation.

Q No. 2 **Answer any FOUR of the following**

a) **Beam engine (crank and lever mechanism).**

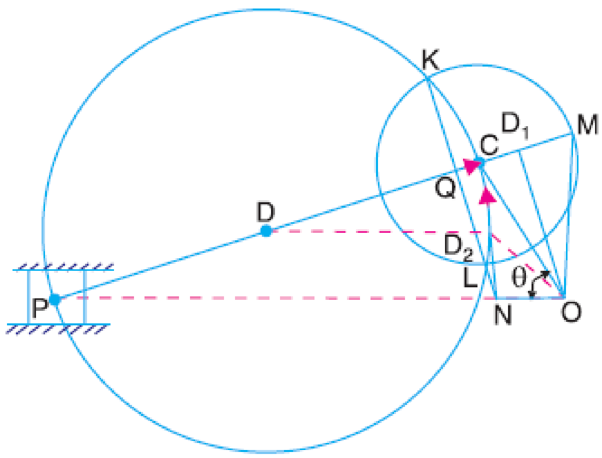
A part of the mechanism of a beam engine (also known as cranks and lever mechanism) which consists of four links is shown in Fig. In this mechanism, when the crank rotates about the fixed centre A, the lever oscillates about a fixed centre D. The end E of the lever CDE is connected to a piston rod which reciprocates due to the rotation of the crank. In other words, the purpose of this mechanism is to convert rotary motion into reciprocating motion. 04



Beam Engine

(sketch 02 marks & Description 02 marks)

b) **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.

(sketch 02 marks & Description 02 marks) 04

c) **Types of followers**

The followers may be classified as discussed below:

1. According to the surface in contact.

(a)Knife edge follower.

When the contacting end of the follower has a sharp knife edge, it is called a knife edge follower. 04

(b) Roller follower.

When the contacting end of the follower is a roller, it is called a roller follower.

(c) Flat faced or mushroom follower.

When the contacting end of the follower is a perfectly flat face, it is called a flat faced follower and when the flat faced follower is circular, it is then called a mushroom follower.

(d) Spherical faced follower.

When the contacting end of the follower is of spherical shape, it is called a spherical faced follower.

2.According to the motion of the follower.

(a) Reciprocating or translating follower.

When the follower reciprocates in guides as the cam rotates uniformly, it is known as reciprocating or translating follower.

(b) Oscillating or rotating follower.

When the uniform rotary motion of the cam is converted into predetermined oscillatory motion of the follower, it is called oscillating or rotating follower.

3. According to the path of motion of the follower.

(a) Radial follower. When the motion of the follower is along an axis passing through the centre of the cam, it is known as radial follower

(b) Off-set follower.

When the motion of the follower is along an axis away from the axis of the cam centre, it is called off-set follower.

d) **Condition for maximum power transmission** — 04

We know that power transmitted by a belt,

$$P = (T_1 - T_2)\,v \quad \ldots(i)$$

where T_1 = Tension in the tight side of the belt

T_2 = Tension in the slack side of the belt

and v = Velocity of the belt in m/s.

We have also seen that the ratio of driving tensions is

$$\frac{T_1}{T_2} = e^{\mu.\theta} \quad \text{or} \quad T_2 = \frac{T_1}{e^{\mu.\theta}} \quad \ldots(ii)$$

Substituting the value of T_2 in equation *(i)*,

$$P = \left(T_1 - \frac{T_1}{e^{\mu.\theta}}\right)v = T_1\left(1 - \frac{1}{e^{\mu.\theta}}\right)v = T_1.v.C \quad \ldots(iii)$$

where $C = 1 - \frac{1}{e^{\mu.\theta}}$

We know that $T_1 = T - T_C$

where T = Maximum tension to which the belt can be subjected , and

T_C = Centrifugal tension in newtons.

Substituting the value of T_1 in equation *(iii)*,

$$P = (T - T_C)\,v.C \qquad (\text{Substituting } T_C = m.\ v^2)$$

$$= (T - m.v^2)\,v.C = (T.v - m\,v^3)\,C$$

For maximum power, differentiate the above expression with respect to v and equate to zero.

i.e. $\frac{dP}{dv} = 0$ or $\frac{d}{dv}(T.v - mv^3)C = 0$

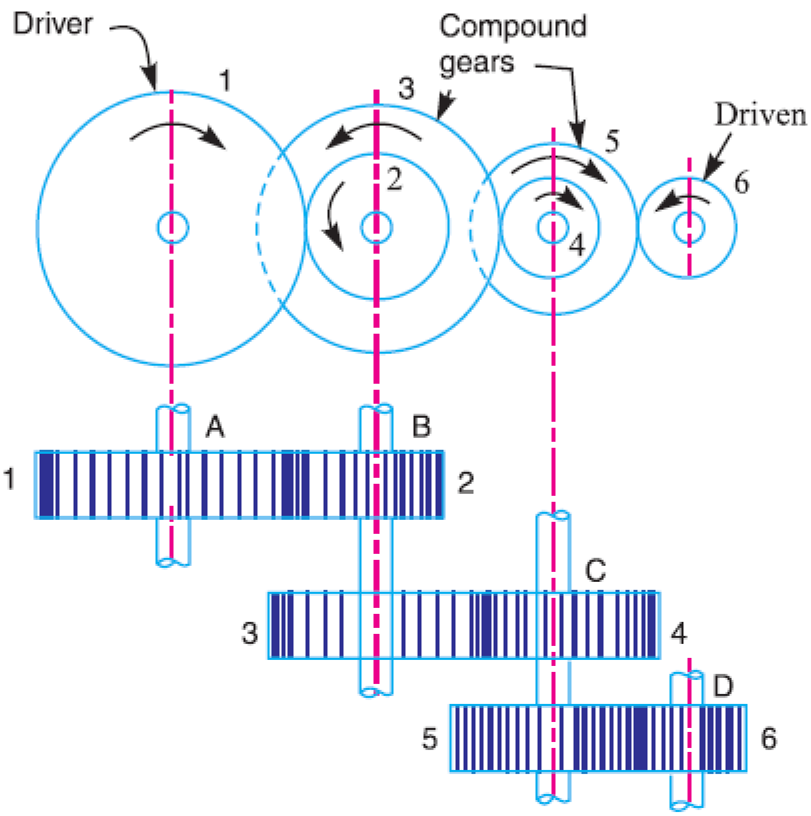
$$\therefore \quad T - 3\,m\,.\,v^2 = 0$$

$$\text{or} \quad T - 3\,T_C = 0 \quad \text{or} \quad T = 3\,T_C \quad \ldots(iv)$$

It shows that when the power transmitted is maximum, 1/3rd of the maximum tension is absorbed as centrifugal tension.

e) **Compound gear train**

When there are more than one gear on a shaft, as shown in Fig. below, it is called a compound train of gear. 04



Compound gear train.

In a compound train of gears, as shown in Fig., the gear 1 is the driving gear mounted on shaft A, gears 2 and 3 are compound gears which are mounted on shaft B. The gears 4 and 5 are also compound gears which are mounted on shaft C and the gear 6 is the driven gear mounted on shaft D.

Let N_1= Speed of driving gear 1, T_1= Number of teeth on driving gear 1,

$N_2, N_3..., N_6$= Speed of respective gears in r.p.m., and

$T_2, T_3..., T_6$= Number of teeth on respective gears.

Since gear 1 is in mesh with gear 2, therefore its speed ratio is

$$\frac{N_1}{N_2} = \frac{T_2}{T_1} \qquad \ldots(i)$$

Similarly, for gears 3 and 4, speed ratio is

$$\frac{N_3}{N_4} = \frac{T_4}{T_3} \qquad \ldots(ii)$$

and for gears 5 and 6, speed ratio is

$$\frac{N_5}{N_6} = \frac{T_6}{T_5} \qquad \ldots(iii)$$

The speed ratio of compound gear train is obtained by multiplying the equations (*i*), (*ii*) and (*iii*),

$$\therefore \quad \frac{N_1}{N_2} \times \frac{N_3}{N_4} \times \frac{N_5}{N_6} = \frac{T_2}{T_1} \times \frac{T_4}{T_3} \times \frac{T_6}{T_5}$$

$$\frac{N_1}{N_6} = \frac{T_2 \times T_4 \times T_6}{T_1 \times T_3 \times T_5}$$

Since gears 2 and 3 are mounted on one shaft B, therefore $N_2 = N_3$.
Similarly gears 4 and 5 are mounted on shaft C, therefore $N_4 = N_5$.

$$i.e. \quad \text{Speed ratio} = \frac{\text{Speed of the first driver}}{\text{Speed of the last driven or follower}}$$

$$= \frac{\text{Product of the number of teeth on the drivens}}{\text{Product of the number of teeth on the drivers}}$$

$$\text{and Train value} = \frac{\text{Speed of the last driven or follower}}{\text{Speed of the first driver}}$$

$$= \frac{\text{Product of the number of teeth on the drivers}}{\text{Product of the number of teeth on the drivens}}$$

04

f) **Numerical on a multiplate clutch**

$n = 3$; $r_i = 50$ mm ; $r_o = 100$ mm

$W = 1.25$ kN $= 1.25 \times 10^3$ N

$\mu = 0.35$; $N = 1600$ r.p.m. $P = ?$

uniform wear theory

$$T = n \cdot \mu \cdot W \cdot R$$

$$R = \frac{r_i + r_o}{2} \quad \text{and} \quad P = \frac{2\pi N T}{60}$$

$$= 75 \text{ mm} = 0.075 \text{ m}$$

$$T = 3 \times 0.35 \times 1.25 \times 10^3 \times 0.075$$

$$\boxed{T = 98.4375 \text{ N-m}}$$ —— 2 marks

$$\therefore P = \frac{2\pi \times 1600 \times 98.4375}{60}$$

$$\boxed{P = 16.4934 \text{ kW}}$$ —— 2 marks

3 a

Sr. No.	Mechanism	Machine	
01	Primary function is used to transmit or modify the motion.	Primary function is to obtain the mechanical advantage.	
02	It is not used to transmit the force.	It is used transmit the force.	
03	A mechanism is a single system to transfer the motion	A machine has one or more mechanism to perform the desired function.	04 Points
04	eg. In watch, energy stored on winding the spring is used to move hands An indicator is used to draw P-V diagram of engine	eg. Shaper receives mechanical power which is used to suitably convert to do work of cutting the metal. A hoist is machine to lift the loads.	01 M each

b

Whitworth quick return motion mechanism. This mechanism is mostly used in shaping and slotting machines. In this mechanism, the link *CD* (link 2) forming the turning pair is fixed, as shown in Fig. The link 2 corresponds to a crank in a reciprocating steam engine. The driving crank *CA* (link 3) rotates at a uniform angular speed. The slider (link 4) attached to the crank pin at *A* slides along the slotted bar *PA* (link 1) which oscillates at a pivoted point *D*. The connecting rod *PR* carries the ram at *R* to which a cutting tool is fixed. The motion of the tool is constrained along the line *RD* produced, *i.e.* along a line passing through *D* and perpendicular to *CD*.

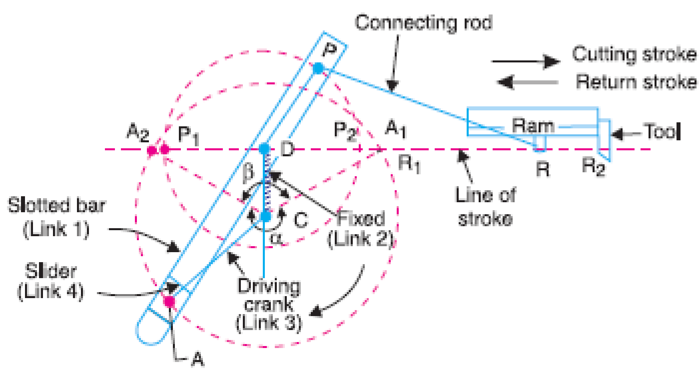


Figure 02 Mark

When the driving crank *CA* moves from the position *CA*1 to *CA*2 (or the link *DP* from the position *DP*1 to *DP*2) through an angle α in the clockwise direction, the tool moves from the left hand end of its stroke to the right hand end through a distance 2 *PD*.

Now when the driving crank moves from the position *CA*2 to *CA*1 (or the link *DP* from *DP*2 to *DP*1) through an angle β in the clockwise direction, the tool moves back from right hand end of its stroke to the left hand end.

A little consideration will show that the time taken during the left to right movement of the ram (*i.e.* during forward or cutting stroke) will be equal to the time taken by the driving crank to move from *CA*1 to *CA*2. Similarly, the time taken during the right to left movement of the ram (or during the idle or return stroke) will be equal to the time taken by the driving crank to move from *CA*2 to *CA*1.

Since the crank link *CA* rotates at uniform angular velocity therefore time taken during the cutting stroke (or forward stroke) is more than the time taken during the return stroke. In other words, the mean speed of the ram during cutting stroke is less than the mean speed during the return stroke.

The ratio between the time taken during the cutting and return strokes is given by

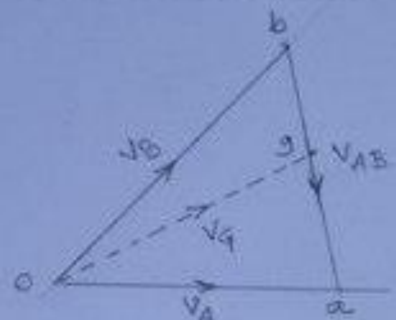
$$\frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{\alpha}{\beta} = \frac{\alpha}{360° - \alpha} \quad \text{or} \quad \frac{360° - \beta}{\beta}$$

Explain 02 Mark

c

Space and Velocity diagram – 02 Marks Calculations – 02 Marks

Space Diagram : scale 1 : 50



Velocity Diagram : Scale 1 : 2.

02 Mark

Given: OB = 130 mm AB = 500 mm. AG = 275 mm

$N_{BO} = 750$ rpm $\omega_{BO} = 2\pi \times \frac{750}{60} = 78.53$ rad/s

$V_{BO} = V_B = \omega_{BO} \times OB = 78.53 \times \frac{130}{1000}$

$V_B = 10.21$ m/sec

From velocity Diagram,

1) velocity of slider 'A'

$V_A =$ vector oa x scale

$= 4.4 \times 2 = 8.8$ m/sec – Ans.

2) velocity of C.G of connecting rod 'G'.

$\frac{AB}{AG} = \frac{ab}{ag}$

$\therefore$ vector $og = ab \times \frac{AG}{AB} = 3.8 \times \frac{275}{500} = 2.09$ mm

$\therefore$ velocity of C.G 'G' = vector 'og' x scale

$V_G = 3.9 \times 2 = 7.8$ m/s – Ans

02 Mark

d

Given

$P = 7.5\ kW = 7500\ W$ $d = 300\ mm = 0.3\ m$

$N = 1600\ rpm$. $\theta = 180° \times \pi/180 = \pi\ rad$, $\mu = 0.3$

$T_{max} = 8\ N/mm$ width.

Velocity of belt

$$V = \frac{\pi d N}{60} = \frac{\pi \times 0.3 \times 1600}{60}$$

$$= 25.13\ m/s$$

Power transmitted

$$P = (T_1 - T_2)V$$

$$7500 = (T_1 - T_2) \times 25.13$$

$$\therefore T_1 - T_2 = 298.45 \quad \text{--- (1)}$$

we know that;

$$2.3 \log\left(\frac{T_1}{T_2}\right) = \mu\theta$$

$$\log\left(\frac{T_1}{T_2}\right) = \frac{0.3 \times 3.142}{2.3}$$

$$= 0.4098$$

$$\therefore \frac{T_1}{T_2} = 2.569 \quad \text{--- (2)}$$

02 Marks

from eq^n (1) & (2)

$$T_1 = 488.67\ N,\ T_2 = 190.21\ N$$

$\therefore$ Maxi Tension in belt

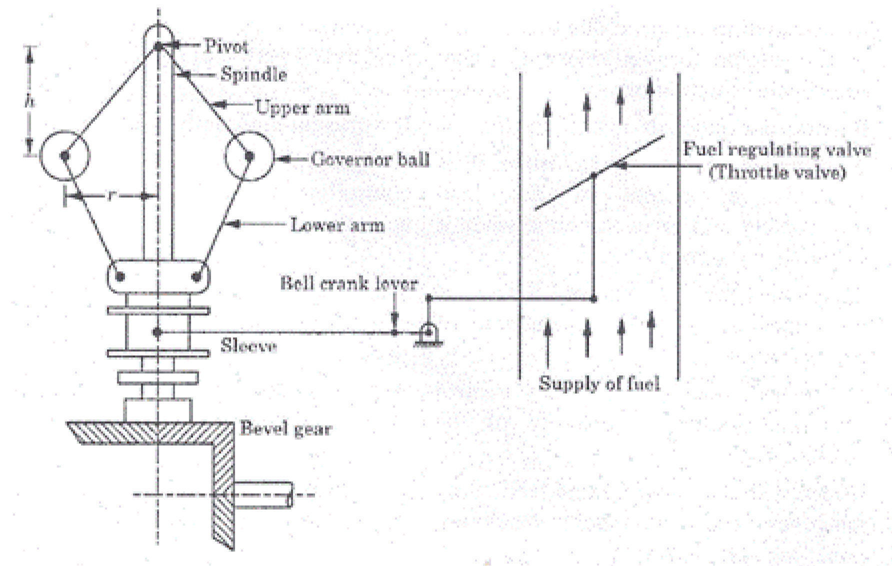
$$= 488.67$$

$$\therefore \text{width of belt} = \frac{T_{max}}{T_{max}/mm \text{ of width}}$$

$$= \frac{488.67}{8}$$

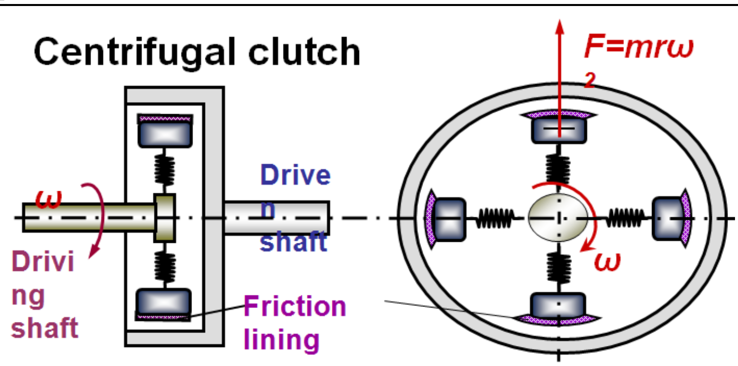
02 Marks

$$\text{width } b. = 61.08\ mm \text{ --- Ans.}$$

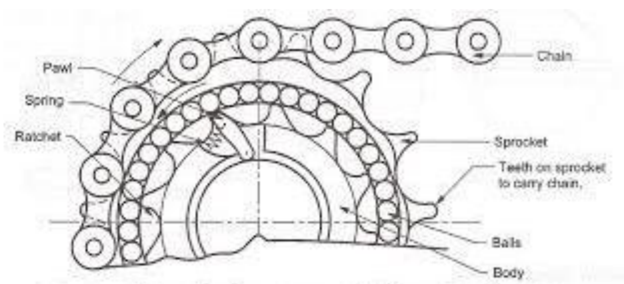
<table>
<tr><td></td><td>e</td><td>Watt's Governor:

Watt governor is the simplest and gravity controlled form of the centrifugal governors. It consists of two fly balls attached to the sleeve of negligible mass. The upper sides of arms are pivoted so that its balls can move upward and downward as they revolve with a vertical spindle. The engine drives the spindle through bevel gears. The lower arms are connected to the sleeves. The sleeve is keyed to the spindle in such a way that revolves with the spindle. At the same time, it can slide up and down according to the spindle speed. Two stoppers are provided at the bottom and top of the spindle to limit the movement sleeve.

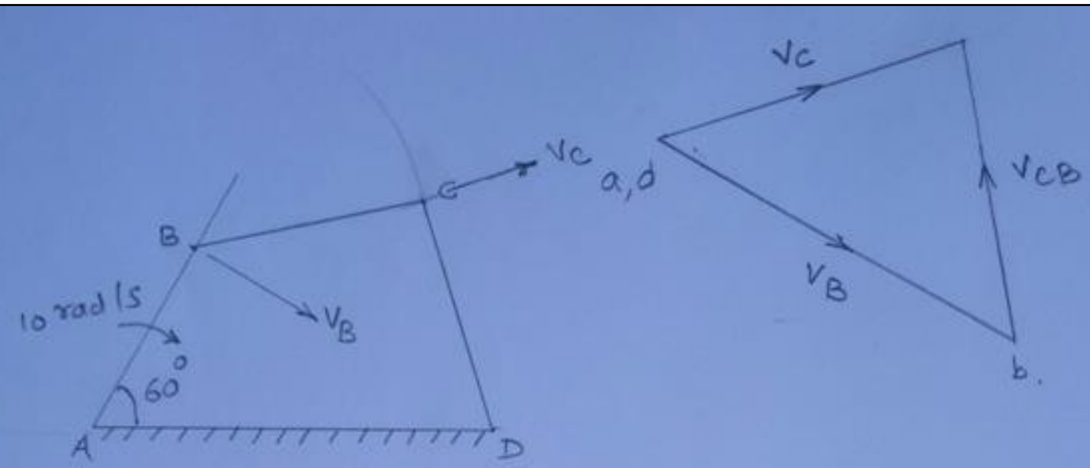
When the load on the engine decreases, the speed of the engine and then the angular velocity of the governor spindle increase. The centrifugal force on ball increase; that tends balls move outward and sleeve move upward. The upward movement of the sleeve actuates a mechanism that operates the throttle valve at the end of "bell crank" lever to decrease the fuel supply. The power output is reduced.

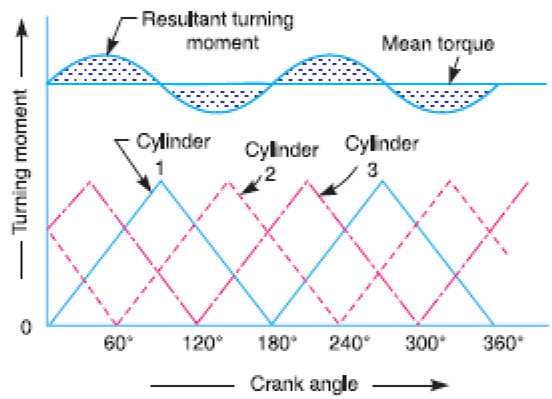
When the speed of the engine decreases as the load on the engine increase, the centrifugal force decreases. The result is that the inward movement fly-balls and downward movement of the sleeve. The movement causes a wide opening of the throttle valve. The increase in the fuel supply also increases engine speed.</td><td>Figure
02 Mark

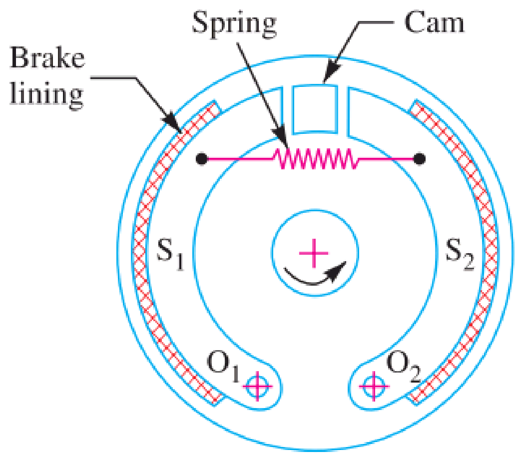
Explain
02 Mark</td></tr>
<tr><td></td><td>f</td><td>
• A centrifugal clutch is a clutch that uses centrifugal force to connect two concentric shafts, with the driving shaft nested inside the driven shaft.
• It consists of number of shoe on the inside of a rim of pulley. The outer surface of pulley is covered with friction material.
• These shoes move radially in guides.
• As the speed of the shaft increase, the centrifugal force on the shoes increases.
• When the centrifugal force is less than the spring force, the shoes remain in the same position as when the driving shaft was stationary, but when the centrifugal force is equal</td><td>Sketch
02 Mark

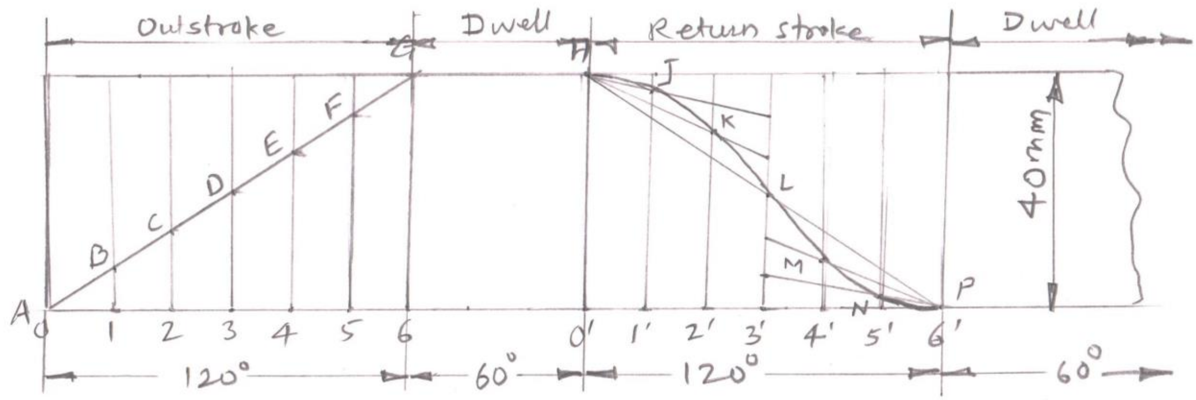
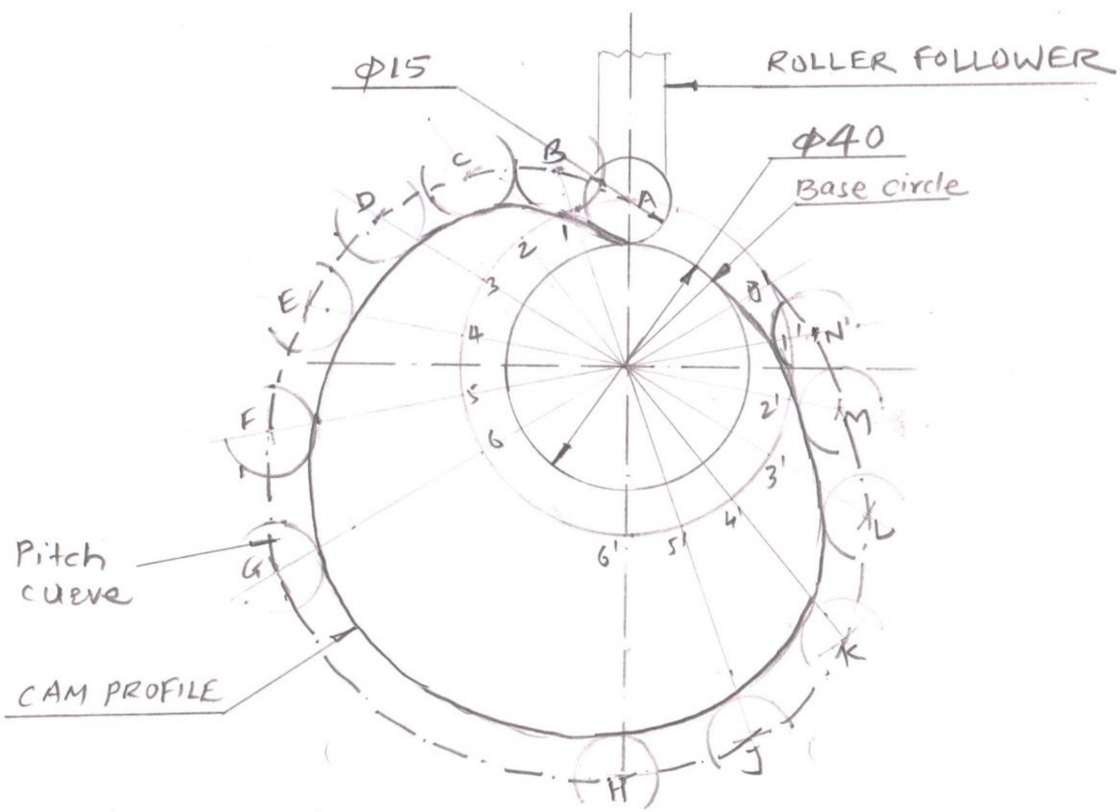
Explain
02 Mark</td></tr>
</table>

		to the spring force, the shoes are just floating. • When the centrifugal force exceeds the spring force, the shoes move outward and come into contact with the driven member presses against it. • The force with which the shoe presses against the driven member is the difference of the centrifugal force and the spring force. • The increase of speed causes the shoe to press harder and enable more torque to be transmitted.	
4	a	A freewheel mechanism on a bicycle allows the rear wheel to turn faster than the pedals. If there is no freewheel on a bicycle, a simple ride could be exhausting, because one could never stop pumping the pedals. And going downhill would be downright dangerous, because the pedals would turn on their own, faster than one could keep up with them.  : Rear wheel arrangement with pawl and rachet Power Train of a bicycle: The power train of a simple bicycle consists of a pair of pedals, two sprockets and a chain. The pedals are affixed to one sprocket — the front sprocket, which is mounted to the bike below the seat. The second sprocket is connected to the hub of the rear wheel. The chain connects the two sprockets. When you turn the pedals, the front sprocket turns. The chain transfers that rotation to the rear sprocket, which turns the rear wheel, and the bicycle moves forward. The faster you turn the pedals, the faster the rear wheel goes, and the faster the bike goes. Coasting: At some point — when going downhill, for instance — speed is high enough so that the rear wheel is turning faster than the pedals. That's when coasting: we stop working the pedals and let the bike's momentum keep moving forward. It's the freewheel that makes this possible. On a bicycle, instead of being affixed to the wheel, the rear sprocket is mounted on a freewheel mechanism, which is either built into the hub of the wheel — a "freehub" — or attached to the hub, making it a true freewheel. Now when you have to move forward, the pawl acts like a hook and gets locked with the teeth - called ratchet and transmits the torque. The complete mechanism is called ratchet and pawl mechanism.	Sketch 02 Mark Explain 02 Mark

		But when you reverse pedal, it falls back and becomes "free". A spring prevents it from falling permanently. This is the reason why you hear the distinct "click-click" sound when you reverse pedal. Also, there are multiple "pawls" placed along the circumference too.	
	b	 Space diagram (scale 1 : 2) Velocity Diagram (Scale 1cm = 0.1 m/s) Given: $AB = 60\ mm = 0.06\ m$ $BC = CD = 70\ mm = 0.07\ m$ $AD = 120\ mm = 0.12\ m$ $\omega_{BA} = 10\ rad/sec$ velocity of crank 'AB': $V_{BA} = V_B = \omega_{BA} \times AB$ $= 10 \times 0.06$ $V_B = 0.6\ m/s$ Angular velo. of link 'BC'; $V_{BC} =$ vector bc × scale. $= 4.4 \times 0.1 = 0.44\ m/s$ $\therefore \omega_{BC} = V_{BC}/BC = 0.44/0.07$ $= 6.28\ rad/sec.$ —— ANS Angular velocity of Link 'CD'; $V_{CD} = V_C =$ vector cd × scale $= 4.6 \times 0.1 = 0.46\ m/s$ $\omega_{CD} = V_{CD}/CD = 0.46/0.07$ $= 6.57\ rad/sec$ —— ANS	Diagram 02 Mark Calculations 02 Mark

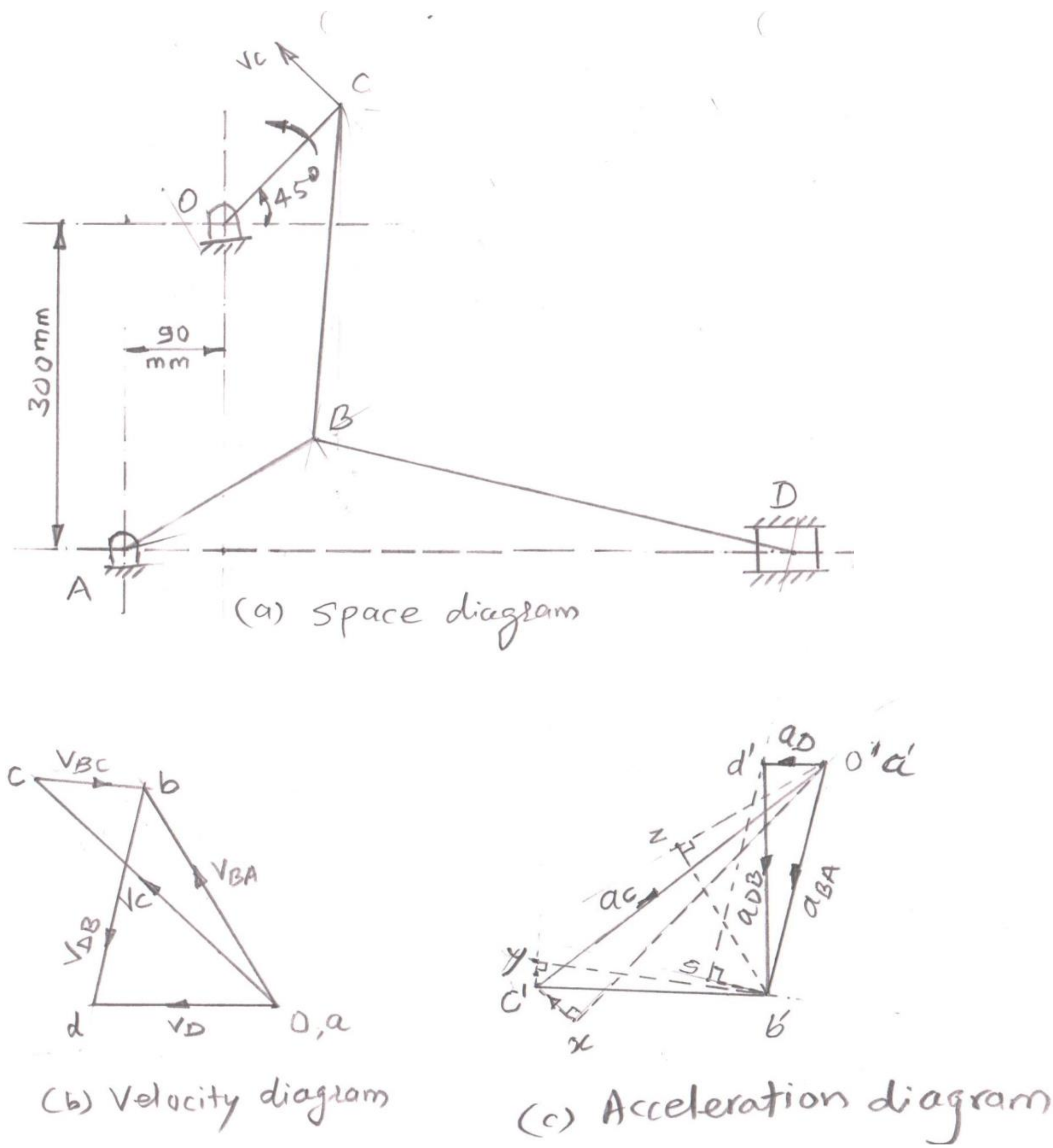
	c	**Advantages of V-belt drive over flat belt drive** **1.** The V-belt drive gives compactness due to the small distance between the centres of pulleys. **2.** The drive is positive, because the slip between the belt and the pulley groove is negligible. **3.** Since the V-belts are made endless and there is no joint trouble, therefore the drive is smooth. **4.** It provides longer life, 3 to 5 years. **5.** It can be easily installed and removed. **6.** The operation of the belt and pulley is quiet. **7.** The belts have the ability to cushion the shock when machines are started. **8.** The high velocity ratio (maximum 10) may be obtained. **9.** The wedging action of the belt in the groove gives high value of limiting ratio of tensions. Therefore the power transmitted by V-belts is more than flat belts for the same coefficient of friction, arc of contact and allowable tension in the belts. **10.** The V-belt may be operated in either direction with tight side of the belt at the top or bottom. The centre line may be horizontal, vertical or inclined.	Any eight 04 Marks
	d	**Working of Flywheel with the help of Turning moment diagram:** A flywheel used in machines serves as a reservoir, which stores energy during the period when the supply of energy is more than the requirement, and releases it during the period when the requirement of energy is more than the supply.  Turning moment diagram for a multi-cylinder engine. The fluctuation of energy may be determined by the turning moment diagram for one complete cycle of operation. Consider the turning moment diagram for a single cylinder double acting steam engine as shown in Fig. We see that the mean resisting torque line *AF* cuts the turning moment diagram at points *B*, *C*, *D* and *E*. When the crank moves from *a* to *p*, the work done by the engine is equal to the area *aBp*, whereas the energy required is represented by the area *aABp*. In other words, the engine has done less work (equal to the area *a AB*) than the requirement. This amount of energy is taken from the flywheel and hence the speed of the flywheel decreases. Now the crank moves from *p* to *q*, the work done by the engine is equal to the area *pBbCq*, whereas the requirement of energy is represented by the area *pBCq*. Therefore, the engine has done more work than the requirement. This excess work (equal to the area *BbC*) is stored in the flywheel and hence the speed of the flywheel increases while the crank moves from *p* to *q*. Similarly, when the crank moves from *q* to *r*, more work is taken from the engine than is developed. This loss of work is represented by the area *C c D*. To supply this loss, the flywheel gives up some of its energy and thus the speed decreases while the crank moves from *q* to *r*. As the crank moves from *r* to *s*, excess energy is again developed given by the area *D d E* and the speed again increases. As the piston moves from *s* to *e*, again there is a loss of work and the speed decreases. The variations of energy above and below the mean resisting torque line are	Sketch 02 Mark Explain 02 Mark

		called ***fluctuations of energy***. The areas *BbC*, *CcD*, *DdE*, etc. represent fluctuations of energy.	
	e	**Internal Expanding shoe brake:**  (*a*) Internal expanding brake. An internal expanding brake consists of two shoes S1 and S2. The outer surface of the shoes are lined with some friction material (usually with Ferodo) to increase the coefficient of friction and to prevent wearing away of the metal. Each shoe is pivoted at one end about a fixed fulcrum O1and O2 and made to contact a cam at the other end. When the cam rotates, the shoes are pushed outwards against the rim of the drum. The friction between the shoes and the drum produces the braking torque and hence reduces the speed of the drum. The shoes are normally held in off position by a spring . The drum encloses the entire mechanism to keep out dust and moisture. This type of brake is commonly used in motor cars and light trucks.	Sketch 02 Mark Explain 02 Mark
	f	Given : d_1 = 400 mm or r_1 = 200 mm ; d_2 = 250 mm or r_2 = 125 mm ; p = 0.35 N/mm^2 ; μ = 0.05 ; N = 105 r.p.m or ω = 2 π × 105/60 = 11 rad/s ; W = 150 kN = 150 × 10^3 N 1. *Power absorbed* We know that for uniform pressure, total frictional torque transmitted, $T = \frac{2}{3} \times \mu . W \left[\frac{(r_1)^3 - (r_2)^3}{(r_1)^2 - (r_2)^2} \right] = \frac{2}{3} \times 0.05 \times 150 \times 10^3 \left[\frac{(200)^3 - (125)^3}{(200)^2 - (125)^2} \right]$ N-mm $= 5000 \times 248 = 1240 \times 10^3$ N-mm $= 1240$ N-m ∴ Power absorbed, $P = T.\omega = 1240 \times 11 = 13640$ W $= 13.64$ kW **Ans.** 2. *Number of collars required* Let n = Number of collars required. We know that the intensity of uniform pressure (p), $0.35 = \frac{W}{n.\pi[(r_1)^2 - (r_2)^2]} = \frac{150 \times 10^3}{n.\pi[(200)^2 - (125)^2]} = \frac{1.96}{n}$ ∴ $n = 1.96 / 0.35 = 5.6$ say 6 **Ans.**	02 Marks for each answer

5	a	(02 marks for displacement diagram and 06 marks for cam profile)  	02 Mark 06 Mark

b

02 marks for configuration diagram , 02 marks for velocity diagram, 02 marks for acceleration diagram and 02 marks for correct answer



02 (configuration diagram)

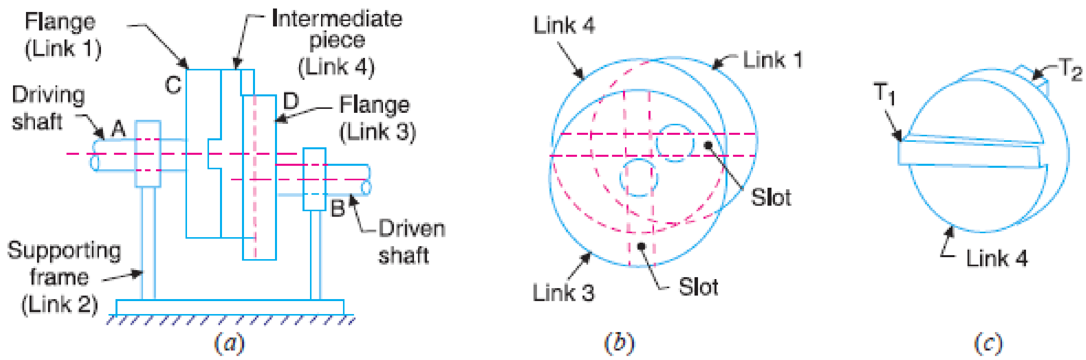
02+02 (velocity and acceleration diagrams)

1. **Velocity of slider 'D' = vector ad = 1.6 m/s**
2. **Acceleration of slider 'D' = vector a'd' = 9.0 m/s²**

02

	c)	We know that velocity of the belt, $v = \frac{\pi . d . N}{60} = \frac{\pi \times 1.2 \times 250}{60} = 15.71$ m/s and Power Transmitted (P) $P = (T_1 - T_2) v$ $7.5 \times 10^3 = (T_1 - T_2) 15.71$ $\therefore T_1 - T_2 = 7500/15.71 = 477.4$ N ----- (i)	01 01
		We know that $\frac{T_1}{T_2} = e^{\mu\theta}$ $\therefore \frac{T_1}{T_2} = e^{0.35 \times 165 \times \pi/180}$ $\therefore \frac{T_1}{T_2} = 2.75$ ------(ii) from eq^n (i) and (ii) $T_1 = 751.8$ N, and $T_2 = 274.4$ N	01
		We know that mass of the belt per meter length, $m = \text{Area} \times \text{length} \times \text{density} = b t l \rho$ $= b \times 0.01 \times 1 \times 1050 = 10.5 b$ kg	01
		$\therefore$ Centrifugal Tension, $T_c = m.v^2 = 10.5\, b\, (15.71)^2 = 2591.44\, b$ N and Max. Tension in the belt, $T = \sigma . b . t = 2 \times 10^6 \times b \times 0.01$ $= 20000\, b$ N	01
		We know that, $T = T_1 + T_c$ $\therefore 20000 b = 751.8 + 2591.44 b$ $\therefore 20000 b - 2591.44 b = 751.8$ $\therefore 17408.56 b = 751.8$ $\therefore b = \frac{751.8}{17408.56}$ $\therefore b = 0.04319$ m $\simeq 43.19$ mm.	01 01 01

6 a)



Oldham's coupling.

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. (a). 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. (b). 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, as shown in Fig. (c). 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.

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.

Marks: 02 (figure), 02 (explanation)

b)

Fluctuations of energy: The variations of energy above and below the mean resisting torque line are called fluctuations of energy.

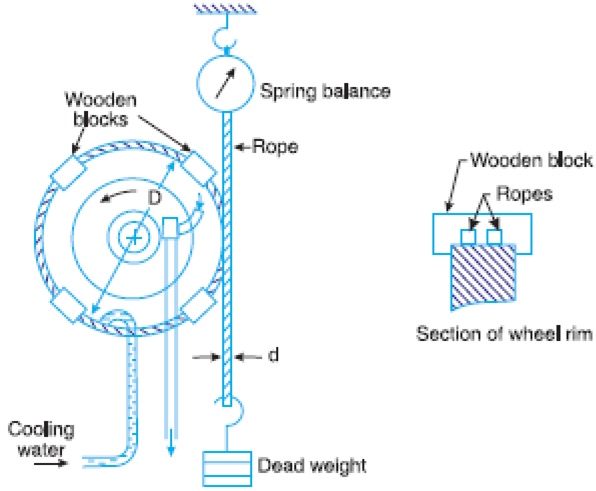
Coefficient of fluctuation of energy: It may be defined as the ratio of the maximum fluctuation of energy to the work done per cycle.
Mathematically,
Coefficient of fluctuation of energy,
E = Maximum fluctuation of energy/Work done per cycle

Coefficient of fluctuation of speed: The difference between the maximum and minimum speeds during a cycle is called the maximum fluctuation of speed. The ratio of the maximum fluctuation of speed to the mean speed is called the coefficient of fluctuation of speed.

Maximum fluctuation of energy:
Δ E = Maximum energy – Minimum energy
= (E + a1) – (E + a1 – a2 + a3 – a4) = a2 – a3 + a4

Marks: 01 for each

c)



Rope brake dynamometer.

02

Rope Brake Dynamometer

It is another form of absorption type dynamometer which is most commonly used for measuring the brake power of the engine. It consists of one, two or more ropes wound around the flywheel or rim of a pulley fixed rigidly to the shaft of an engine. The upper end of the ropes is attached to a spring balance while the lower end of the ropes is kept in position by applying a dead weight as shown in Fig. In order to prevent the slipping of the rope over the flywheel, wooden blocks are placed at intervals around the circumference of the flywheel. In the operation of the brake, the engine is made to run at a constant speed. The frictional torque, due to the rope, must be equal to the torque being transmitted by the engine. 02

Let W = Dead load in newtons,

S = Spring balance reading in newtons,

D = Diameter of the wheel in metres,

d = diameter of rope in metres, and

N = Speed of the engine shaft in r.p.m.

∴ Net load on the brake

$= (W - S)$ N

We know that distance moved in one revolution

$= \pi(D + d)$ m

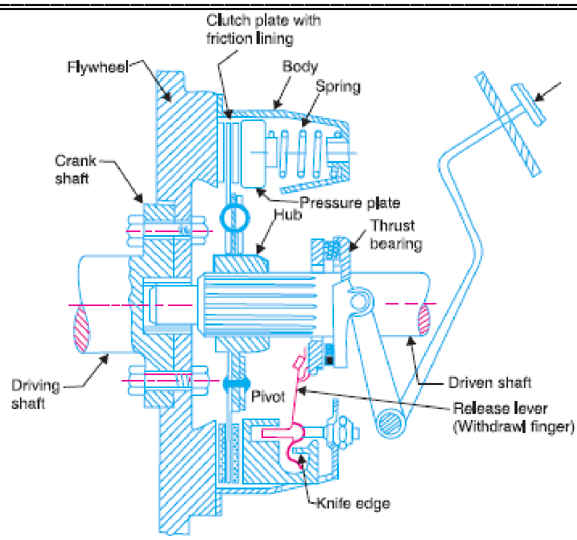
∴ Brake power of the engine,

$$B.P = \frac{\text{Work done per min}}{60} = \frac{(W - S)\,\pi\,(D + d)N}{60} \text{ watts}$$

If the diameter of the rope (d) is neglected, then brake power of the engine,

$$B.P. = \frac{(W - S)\,\pi D\,N}{60} \text{ watts}$$

d)



02

Single disc or plate clutch.

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). It is mounted on the hub which is free to move axially along the splines of the driven shaft. 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. The three levers (also known as release levers or fingers) are carried on pivots suspended from the case of the body. These are arranged in such a manner so that the pressure plate moves away from the flywheel by the inward movement of a thrust bearing. The bearing is mounted upon a forked shaft and moves forward when the clutch pedal is pressed. When the clutch pedal is pressed down, its linkage forces the thrust release bearing to move in towards the flywheel and pressing the longer ends of the levers inward. The levers are forced to turn on their suspended pivot and the pressure plate moves away from the flywheel by the knife edges, thereby compressing the clutch springs. This action removes the pressure from the clutch plate and thus moves back from the flywheel and the driven shaft becomes stationary. On the other hand, when the foot is taken off from the clutch pedal, the thrust bearing moves back by the levers. This allows the springs to extend and thus the pressure plate pushes the clutch plate back towards the flywheel. The axial pressure exerted by the spring provides a frictional force in the circumferential direction when the relative motion between the driving and driven members tends to take place. If the torque due to this frictional force exceeds the torque to be transmitted, then no slipping takes place and the power is transmitted from the driving shaft to the driven shaft.

02

02

e)

Reasons for balancing of rotating elements of machine: The balancing of the moving parts both rotating and reciprocating of such machine is having greater importance. Because, if these parts are not balanced properly then the unbalanced dynamic forces can cause serious consequences, which are harmful to the life of the machinery itself, the human beings and all the property around them. These unbalanced forces not only increase the load on the bearings and stresses in various members, but also produces unpleasant and dangerous vibrations in them.

02

Concept of balancing: When a mass moves **in** circular pitch, it experience a centripetal acceleration which generates a force acting towards the center of rotation. An equal and opposite force which is acting radially outwards which is called centrifugal force. This force is the disturbing force for the system. The magnitude of this force remains constant but the direction goes on changing with the rotation of mass. The centrifugal force , on a rotating machine can be expressed mathematically as follows:

$Fc = m.\ \omega^2.r$ Newton

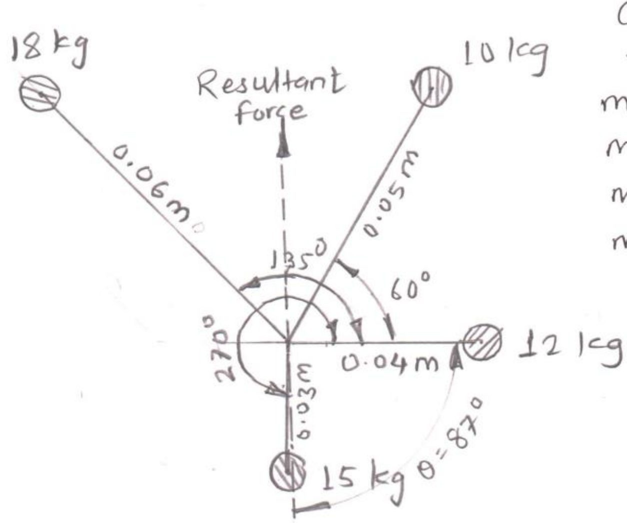
Where, m = Mass of rotating part in kg,

Ω = angular speed of this part in rad/sec, and

r = Distance of the center of gravity of mass from the axis of rotation of part in m.

For the balance of rotating masses, it is the centrifugal force which is to be balanced. This type of problem is very common in steam turbine rotors, engine crank shafts, rotory compressors and centrifugal pumps.

f)



a) Space Diagram.

Centrifugal force of each mass

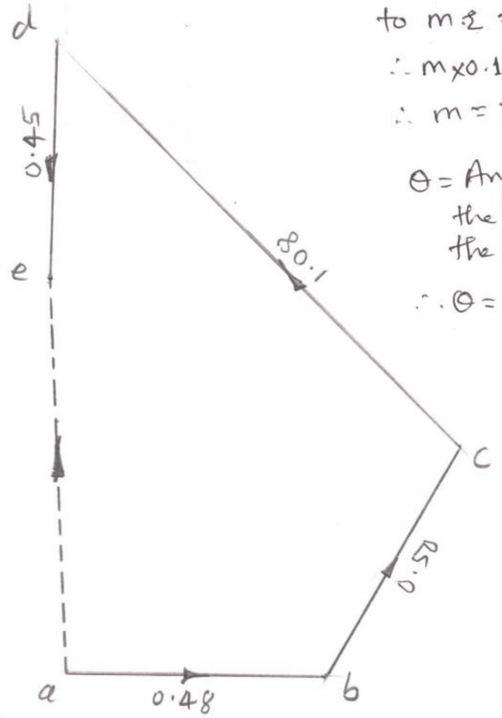
$m_1 r_1 = 12 \times 0.04 = 0.48$ kg-m

$m_2 r_2 = 10 \times 0.05 = 0.50$ kg.m

$m_3 r_3 = 18 \times 0.06 = 1.08$ kg-m

$m_4 r_4 = 15 \times 0.03 = 0.45$ kg-m

02



b) Vector Diagram.

Balancing force is proportional to m r = vector a e

$\therefore m \times 0.1 = 0.75$ kg-m

$\therefore m = 7.5$ kg ....Ans.

θ = Angle of inclination of the balancing mass from the horizontal mass 12 kg

$\therefore \theta = 87^\circ$ (clockwise)....Ans.

02
