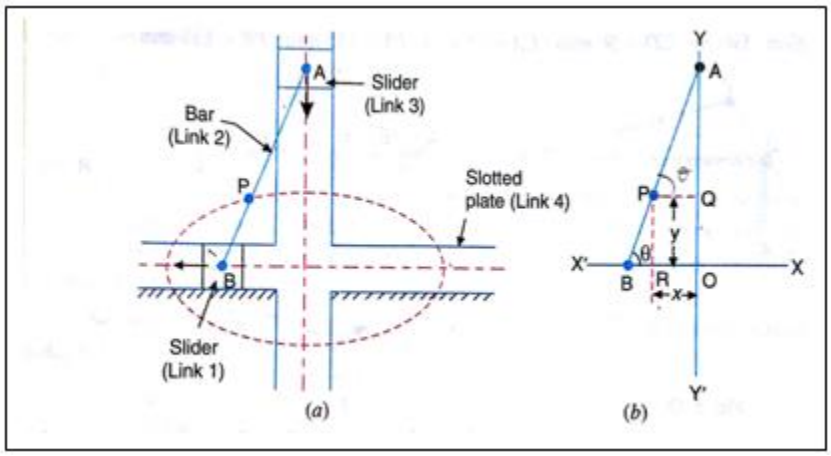
SUMMER – 2022 EXAMINATION

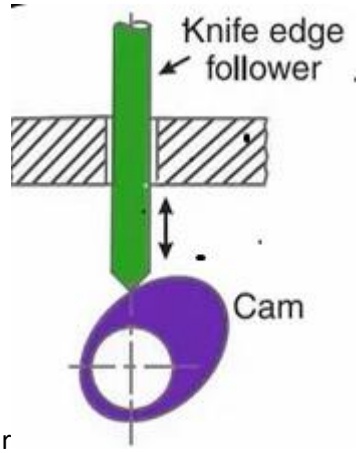
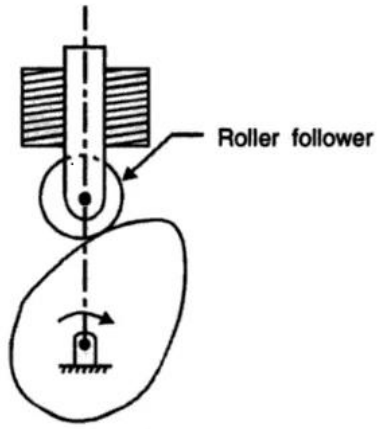
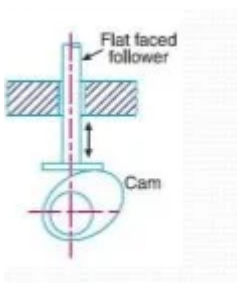
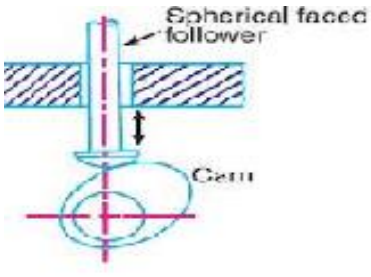
Subject Name: Theory of Machines and Mechanisms **Model Answer** **Subject Code:** **22438**

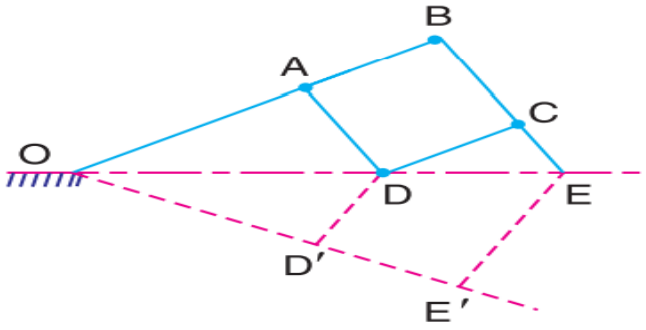
Important Instructions to examiners:

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.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

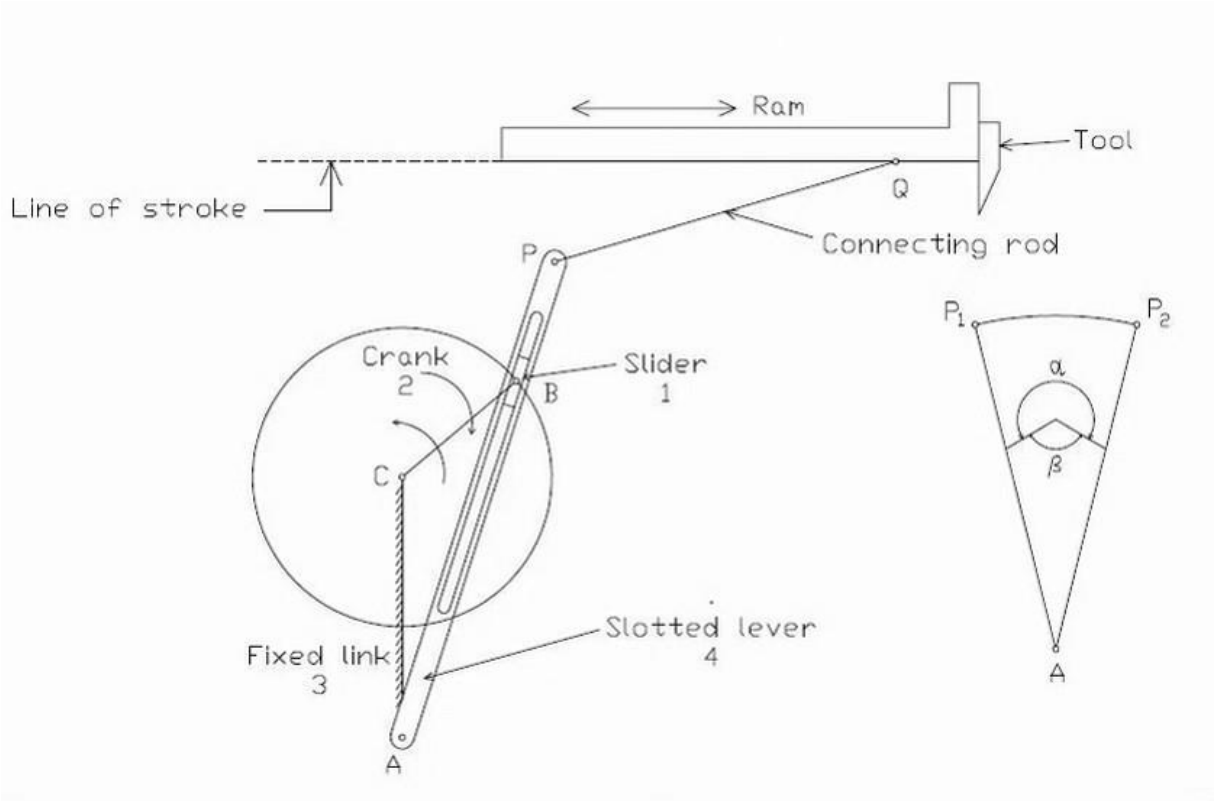
Q. No.	Sub Q. N.	Answer	Marking Scheme
1		Attempt any **FIVE (5X2)**	10
	a)	**Define(i) kinematic link -**Each part of a machine, which moves relative to some other part, is known as a ***kinematic link*** (or simply link) or ***element***. ii) The two links or elements of a machine, when in contact with each other, are said to form a pair. If the relative motion between them is completely or successfully constrained (i.e. in a definite direction), the pair is known as kinematic pair.	1 1
	b)	i) Scotch yoke mechanism ii) slider crank mechanism iii) Beam engine	1 each
	c)	V= r ω ,v= linear velocity in meter per second, r= radius in meter or length of link, ω = angular velocity in radian per second	2
	d)	**1.** Uniform velocity, **2.** Simple harmonic motion, **3.** Uniform acceleration and retardation, and **4.** Cycloidal motion.	½ each
	e)	(i) Stationary gas and oil engines and aircraft engines. (ii) valves of automobile engines	1 each
	f)	i)The brake is used to stop or slow down the rotating wheels of a vehicle where as clutch transfers power from the cars driving shaft and is used to start and stop the vehicle. ii) Brakes help in absorbing power whereas clutch is help in delivering power	02
	g)	i)Height of governor-It is the vertical distance from the centre of the ball to a point where the axes of the arms (or arms produced) intersect on the spindle axis. It is usually denoted by *h*.	1 each

		ii) *Equilibrium speed* of governor It is the speed at which the governor balls, arms etc., are in complete equilibrium and the sleeve does not tend to move upwards or downwards.	
2		Attempt any THREE (3X4)	12
	a)	Elliptical trammels. It is an instrument used for drawing ellipses. This inversion is obtained by fixing the slotted plate (link 4), as shown in Fig. The fixed plate or link 4 has two straight grooves cut in it, at right angles to each other. The link 1 and link 3, are known as sliders and form sliding pairs with link 4. The link AB (link 2) is a bar which forms turning pair with links 1 and 3.When the links 1 and 3 slide along their respective grooves, any point on the link 2 such as P traces out an ellipse on the surface of link 4, as shown in Fig. 5.34 (a). A little consideration will show that AP and BP are the semi-major axis and semi-minor axis of the ellipse respectively. This can be proved as follows : Let us take OX and OY as horizontal and vertical axes and let the link BA is inclined at an angle □ with the horizontal, as shown in Fig. 5.34 (b). Now the co-ordinates of the point P on the link BA $x = PQ = AP \cos \theta$ _; and $y = PR = BP \sin \theta$ _ will be $x/AP = \cos \theta$ and $y/BP = \sin \theta$ Squaring and adding, $(x/AP)^2 + (y/BP)^2 = \cos^2 \theta + \sin^2 \theta = 1$ This is the equation of an ellipse. Hence the path traced by point *P* is an ellipse whose semi major axis is *AP* and semi-minor axis is *BP*.  	02 02

	b)	Diameter of pulley (D) = 600 mm Speed N= 200 RPM Coefficient of friction= 0.25 Angle of lap **θ** =165Xπ/180=2.879 rad (T_1)Maximum tension in belt=2550 N $T_1/T_2 = e^{\mu\theta} = e^{0.25x2.879}$ **T_1= 2.0539T_2** **Maximum tension(T_1) = 2.0539T_2** **T_2= 2550/2.0539=1241.540 N and T_1= 2.009X1244.4=2550** **Power transmitted (P)= (T_1-T_2)xV** **V= πIDN/60= πX600X200/1000X60=6.2831 m/sec** **P= (2550-1241.54)X6.2831=8221.054 watt** **Power transmitted by belt= 8.221kW**	1 1 1 1
	c)	 i) follower  ii(Cam with roller follower   iii)Cam with flat faced follower iv) Cam with spherical faced follower	01 each

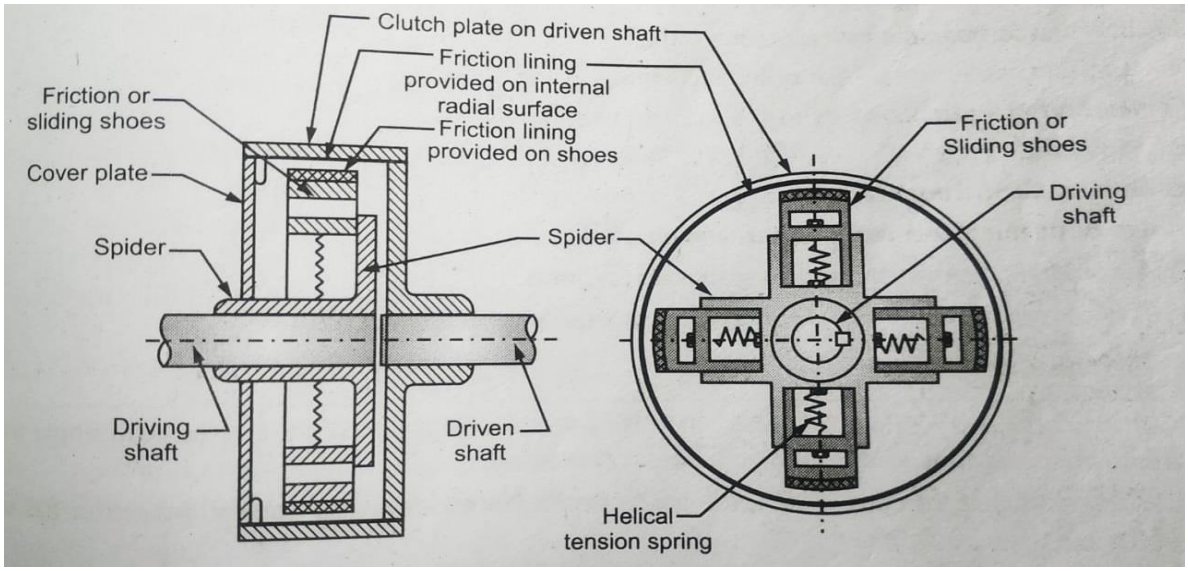
	d)	Tabular method- Let TA = Number of teeth on gear A, and TB = Number of teeth on gear B. First of all, let us suppose that the arm is fixed. Therefore the axes of both the gears are also fixed relative to each other. When the gear A makes one revolution anticlockwise, the gear B will make *TA / TB revolutions, clockwise. Assuming the anticlockwise rotation as positive and clockwise as negative, we may say that when gear A makes + 1 revolution, then the gear B will make (– TA / TB) revolutions. This statement of relative motion is entered in the first row of the table Secondly, if the gear A makes + x revolutions, then the gear B will make – x × TA / TB revolutions. This statement is entered in the second row of the table. In other words, multiply the each motion (entered in the first row) by x. Thirdly, each element of an epicyclic train is given + y revolutions and entered in the third row. Finally, the motion of each element of the gear train is added up and entered in the fourth row. * We know that NB / NA = TA/ TB. Since NA = 1 revolution, therefore NB = TA / TB.	04
3		**Attempt any THREE of the following. (3 X 4 =12)**	12
	a)	Draw a neat sketch of pantograph and explain its working. A pantograph is an instrument used to reproduce to an enlarged or a reduced scale and as exactly as possible the path described by a given point. It consists of a jointed parallelogram ABCD as shown in Fig. It consists of four turning pairs. It is inversion of four bar chain. The bars BA and BC are extended to O and E respectively, such that OA/OB = AD/BE Thus, for all relative positions of the bars, the triangles OAD and OBE are similar and the points O, D and E are in one straight line. Point E traces out the same path as described by point D. From similar triangles OAD and OBE, we find that OD/OE = AD/BE Let point O be fixed and the points D and E move to some new positions D' and E'. Then OD/OE = OD'/OE' . Similarly, if E is constrained to move in a straight line, then D will trace out a straight line parallel to the former. A pantograph is mostly used for the reproduction of plane areas and figures such as maps, plans etc., on enlarged or reduced scales. It is also used to guide cutting tools on lathe machine and milling machine, engraving machines. A modified form of pantograph is used to collect power at the top of an electric locomotive.  	02 02

	b)	Draw a neat sketch of the mechanism used in shaper machine, to achieve the quick return stroke.	04



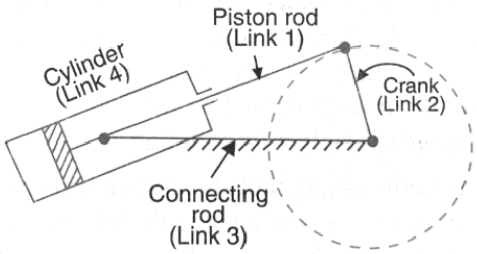
Note- sketch of Whitworth Quick return motion mechanism is also acceptable.

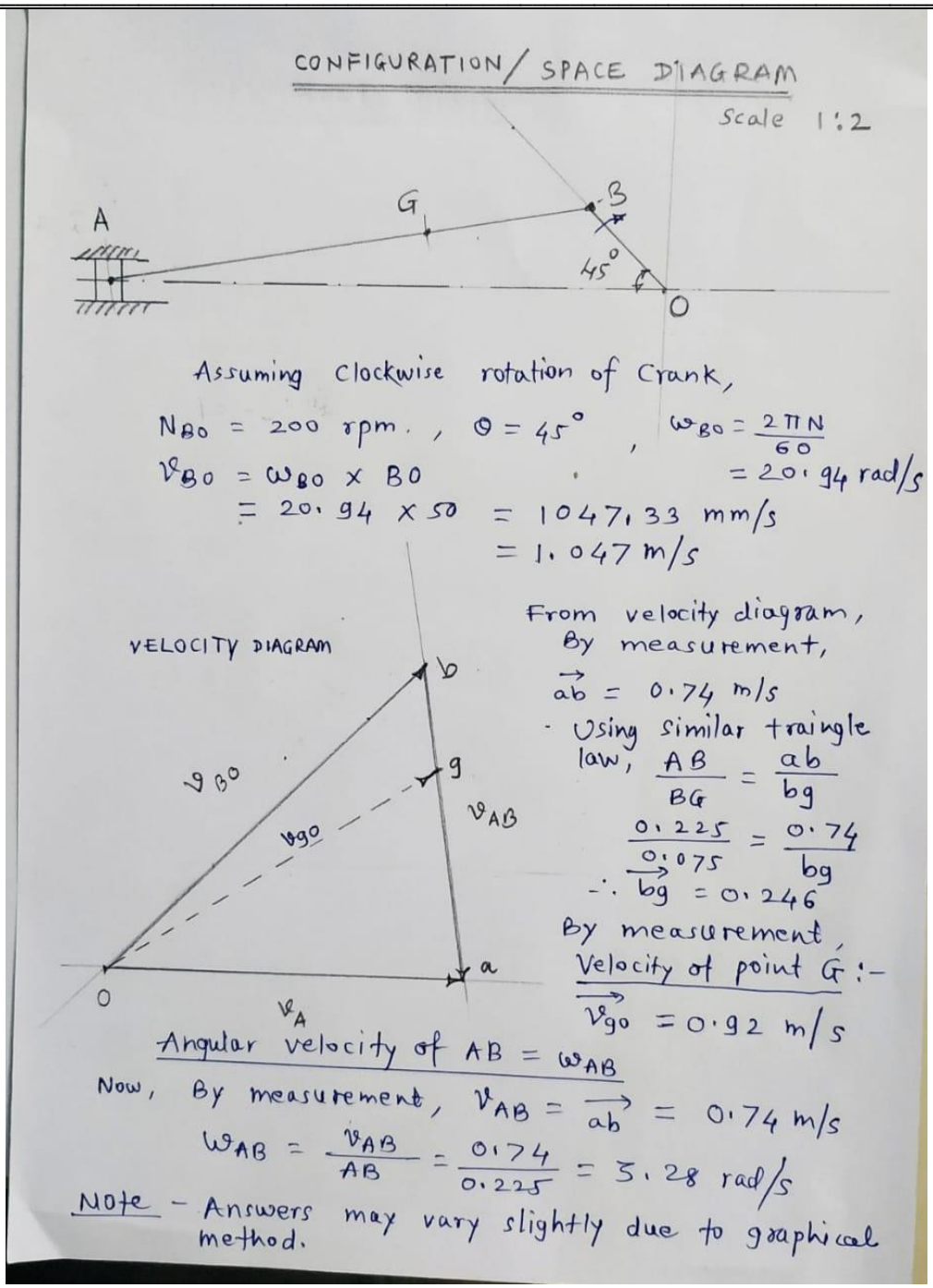
	c)	Explain the working principle of centrifugal clutch,using neat sketch.	02



The centrifugal clutches are usually incorporated into the motor pulleys. It consists of a number of shoes on the inside of a rim of the pulley, as shown in Fig. The outer surface of the shoes are covered with a friction material. These shoes, which can move radially in guides, are held against the boss (or spider) on the driving shaft by means of springs. The springs exert a radially inward force which is assumed constant. The mass of the shoe, when revolving, causes it to exert a radially outward force (i.e. centrifugal force). The magnitude of this centrifugal force depends upon the speed at which the 02

		shoe is revolving. When the centrifugal force is less than the spring force, the shoe remains in the same position as when the driving shaft was stationary, but when the centrifugal force is equal to the spring force, the shoe is just floating. When the centrifugal force exceeds the spring force, the shoe moves outward and comes into contact with the driven member and 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. Using a centrifugal clutch on engine driven equipment enables the engine to be started under a no-load situation. When the engine is idling the drive remains disengaged. Only when the rpm of the engine is increased to the set engagement speed of the clutch or above will the drive be fully connected. This results in a smooth engagement .	
	d)	For high speed applications, roller follower is preferred over knife edge follower. State true or false and justify your answer. True. The fundamental justification for choosing a roller follower versus a knife-edge follower is-Due to the sliding motion of the knife-edge follower on the cam plate, there is increased friction, which causes the cam plate to wear down more quickly and requires more power to drive the cam. In case of knife edge follower there is sliding motion between the contacting surface of cam and follower. For high-speed applications, rate of wear will also increase for knife edge follower due to sliding friction and small contact area. Because of small contact area, there is excessive wear, knife edge follower 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	01 03
	e)	Define the term Co-efficient of fluctuation of speed, and co-efficient of fluctuation of energy as applied to flywheel. State their significance. **Co-efficient of fluctuation of speed(Cs)** -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. Let N1 and N2 are maximum and minimum speed in rpm during cycle. N is average speed , i.e. N= (N1+N2)/2 Cs= (N1-N2)/N **co-efficient of fluctuation of energy(C_E) -** 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, C_E =Maximum fluctuation of energy/ Work done per cycle The work done per cycle (in N-m or joules) may be obtained by using the following relation: Work done per cycle = $T_{mean} \times \theta$ where T_{mean} = Mean torque, and θ = Angle turned (in radians), in one revolution. = 2π, in case of steam engine and two stroke internal combustion engines = 4π, in case of four stroke internal combustion engines. Significance- The coefficient of fluctuation of speed is a limiting factor in the design of flywheel. It varies depending upon the nature of service to which the flywheel is employed. Coefficient of fluctuation of energy guides us for selection of engine for particular application. E. g. whether to go for single cylinder/multicylinder engine/ four stroke/two stroke engines	1 1 2

4		**Attempt any TWO of the following. (2 X6 =12)**	12
	a)	Draw a neat sketch of oscillating cylinder engine and explain its construction.	
			2
		inks and their motions - Connecting rod (link 3) - Fixed Crank (Link 2) -Rotating Piston and rod (link 1)- Reciprocating Cylinder (link 4)- Oscillating	1
		Pairs - Turning – Crank and Connecting rod Turning – Crank & piston rod Sliding – Piston rod & Cylinder. Turning – Cylinder and connecting rod	1
		Construction – This mechanism is an inversion of Single slider crank chain, which is obtained by fixing connecting rod. It has three turning pairs & one Sliding pair. As shown in figure, both rod & piston form one link. There is no relative motion between rod &Piston. The cylinder is pivoted to frame, due to which whole cylinder is free to oscillate about the frame.The mechanism is used where rotary motion is converted into oscillating motion. It is used in printing press machine.	2
	b)	In the engine mechanism, crank OB=50 mm, length of connecting rod = 225 mm.The Centre of gravity of the rod is at 'G' which is 75 mm from 'B'. The speed is 200 rpm, and the crank OB is rotated at 45^{o}from 'OA'. Find out the velocity of point 'G' and angular velocity of AB by relative velocity method.	



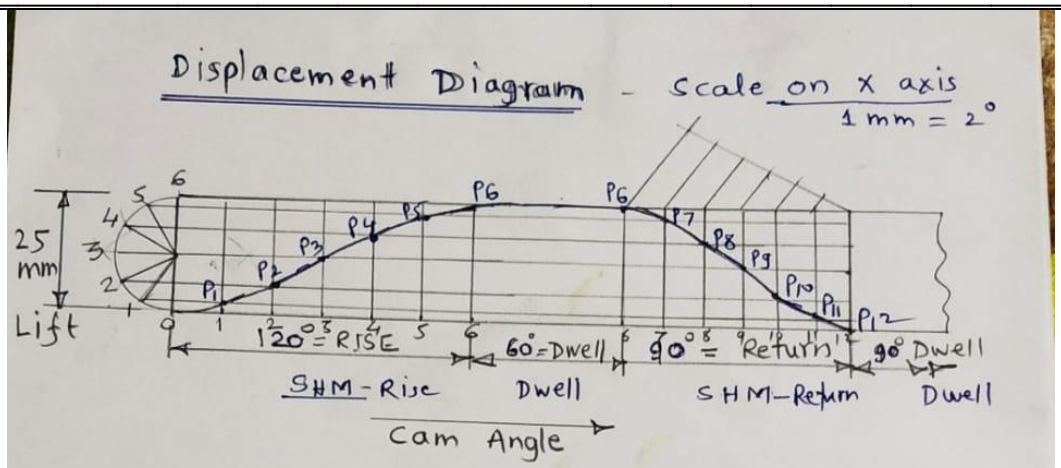
2

2

1

1

c) A disc cam rotating in a clockwise direction is used to move a reciprocating roller with simple Harmonic Motion in a radial path, as given below
(i) Outstroke with maxi. displacement of 25 mm during 120° of camrotation
(ii) Dwell for 60° of cam rotation
(iii) Return stroke with maxi displacement of 25 mm during 90° of camrotation, and dwell for remaining period.
Draw the cam profile, when the maximum cam radius is 20 mm. Take roller diameter as 8 mm.



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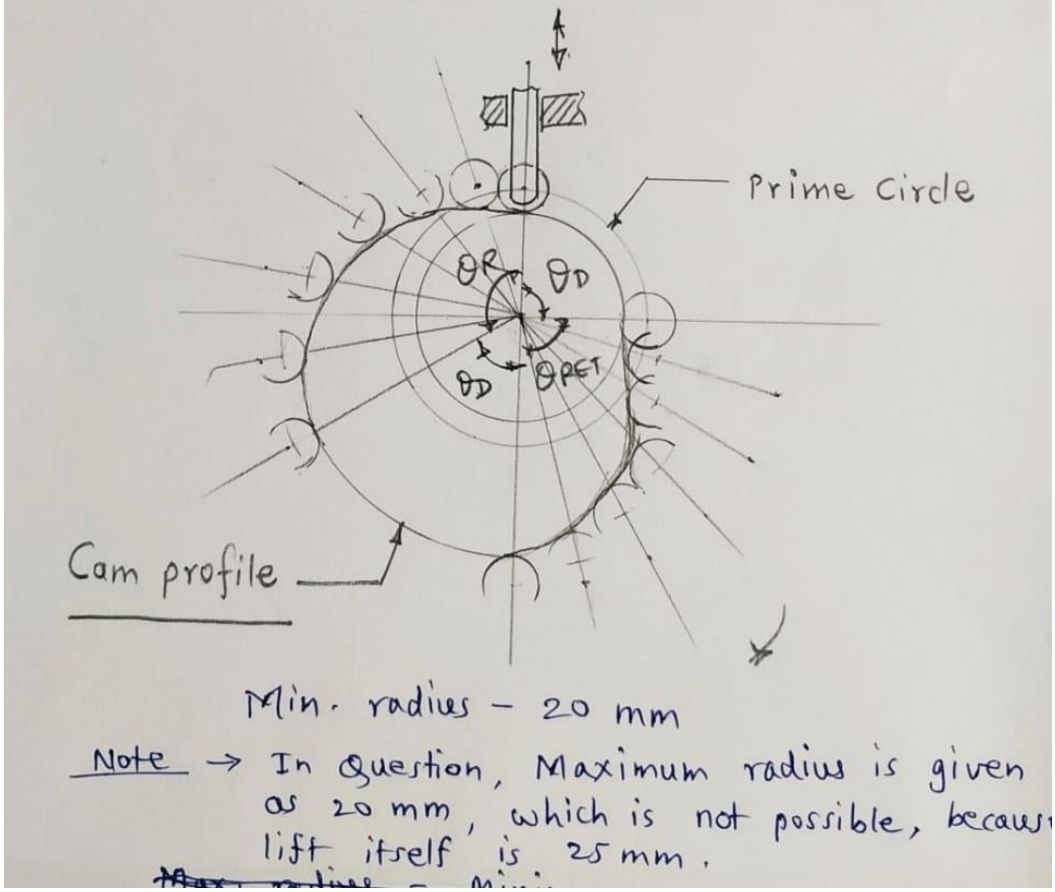


3

Min. radius – 20 mm

Note → In Question, Maximum radius is given as 20 mm, which is not possible, because lift itself is 25 mm.

5		Attempt any **TWO** of following(2x6=12)	12
	a)		1 mark each

Sr. No.	Application	Power Transmission and Justification
I.	Electric Two Wheeler (Battery Operated)	For Starting V belt drive, For transmission of power Controller
II.	Floor Mill	Flat/ V belt, Constant Velocity ratio; compact
III.	JCB Wrist Watch	Mechanical drive (Gear Drive) / Hydraulic drive
IV.	Wrist watch	Gear drive, Constant Velocity ratio; Accuracy
V.	Stone crusher	Gear drive; Speed Reduction, more torque
VI.	Road Roller	Mechanical (Gear drive) / Hydraulic Drive with Gear (New Machines) .Speed Reduction, more torque.

b)

Given :

Crank radius; r = 200 mm = 0.2 m; Length of connecting rod; l = 800 mm = 0.8 m;

Rotational Speed; N = 500 RPM; Angular speed ω = (2πN)/60= (2 X 3.14 X 500)/60 = 52.33 rad/sec; Obliquity ratio; n= l/r =0.8/0.2 =4 — 03

Crank Angle (θ)= 60^0

Velocity of Piston $V_P = \omega * r(\sin\theta + \frac{\sin 2\theta}{2*n})$ — 03

$52.33*0.2*\left(\sin 60 + \frac{\sin 120}{2*4}\right) = 10.46*\left(0.866 + \frac{0.866}{8}\right) =$ **10.190 m/sec**

Velocity of Piston = 10.190 m/sec

Acceleration of Piston

$$\alpha_P = \omega^2 * r(\cos\theta + \frac{\cos 2\theta}{n})$$

$$52.33^2 * 0.2 * \left(\cos 60 + \frac{\cos 120}{4}\right) = 2738.0 * 0.2 * \left(0.5 + \frac{-0.5}{4}\right) = 205.35 \text{ m/sec2}$$

Acceleration of Piston= 205.35 m/sec²

c)

Solution.

a) Analytical method

The magnitude and direction of the balancing mass may be obtained, analytically, as discussed below : Resolve the centrifugal forces horizontally and vertically and find their

sums,i.e.

$\Sigma H = m_1 . r_1 \cos\theta_1 + m_2 . r_2 \cos\theta_2 + \ldots\ldots$

$\Sigma V = m_1 . r_1 \sin\theta_1 + m_2 . r_2 \sin\theta_2 + \ldots\ldots$

Magnitude of the resultant centrifugal force,

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

If θ is the angle, which the resultant force makes with the horizontal, then

$$\tan\theta = \frac{\Sigma V}{\Sigma H}$$

Given :

m_1 = 12 kg ; m_2 = 15 kg ; m_3 = 18kg ; m_4 = 20 kg ; 01

r_1 = 0.04 m ; r_2 = 0.05 m ; r_3 = 0.06 m ; r_4 = 0.03 m ;

$\theta_1 = 0°$; $\theta_2 = 60°$; $\theta_3 = 135°$; $\theta 4 = 270°$;

Balance mass radius r = 0.1 m

Since the magnitude of centrifugal forces are proportional to the product of each mass and its radius, therefore 02

$m_1 r_1$ = 12 x 0.04= 0.48 kg-m;

$m_2 r_2$ = 15 x 0.05 = 0.75 kg-m; 02

$m_3 r_3$ = 18 x 0.06 = 1.08 kg-m;

$m_4 r_4$ = 20 x 0.03 = 0.6 kg-m

ΣH = 0.48 cos0 + 0.75 cos60 + 1.08 cos135 + 0.6 cos270 =0.0914 kg.m

ΣV = 0.48 sin0 + 0.75sin60 + 1.08sin135 + 0.6sin270 = 0.8131 kg.m 01

$F_C = \sqrt{(0.0914)^2 + (0.8131)^2} = 0.8181$ kg.m;

$\therefore F_C = m . r$,

0.8181= 0.1× m ; **m = 8.181 kg Ans**

$\tan\theta = \frac{\Sigma V}{\Sigma H}$ = 0.8131/ 0.0914=8.90 θ = - 1.85^0

θ = 90°- 1.85° = 88.15°

or

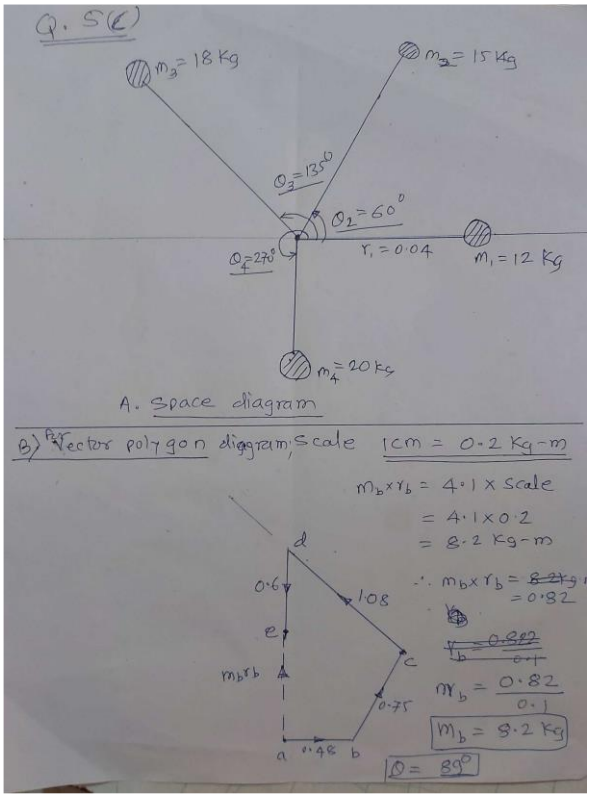
b) Graphical Method

$m_1 r_1$ = 12 x 0.04 = 0.48 kg-m;

$m_2 r_2$ = 15 x 0.05 = 0.75 kg-m;

$m_3 r_3$ = 18 x 0.06 = 1.08 kg-m;

$m_4 r_4$ = 20 x 0.03 = 0.6 kg-m



6		Attempt any TWO of following(2x6=12)	12

a)

Need of Chain lubrication

To reduce friction and wear between various parts of chain as links rollers bushes and sprockets. — 02

- To remove wear particles, foreign particles etc.
- To increase power transmission.
- To reduce maintenance cost.
- To increase life of system. — 01

Various methods of chain Lubrication.

1. Manual Lubrication.
2. Drip Lubrication
3. Oil bath lubrication — 03

Manual lubrication- In this lubrication the oil is applied to elements of chain and sprocket. The oil is applied through brush or cotton. The frequency of lubrication is decided depending upon the use of chain drive . It may be daily; after shift or some two or three days, week.

Drip Lubrication - In this lubrication the oil is dripped on elements of chain and sprocket. The drip speed is decided depending on application and speed of chain. A drip pipe or system is used.

Oil bath lubrication - In this lubrication the oil is applied inserting some part of chain in oil bath. The oil bath is always maintained at particular level.

b)

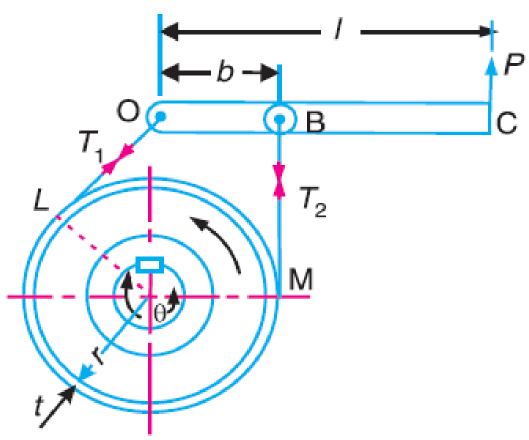
Given :

d = 450 mm or r = 225 mm = 0.225 m ; T_B = 225 N-m ; b = OB = 100 mm = 0.1 m ;

l = 500 mm = 0.5 m ; μ = 0.25

Let P = Operating force.

Operating force when drum rotates in anticlockwise direction — 02



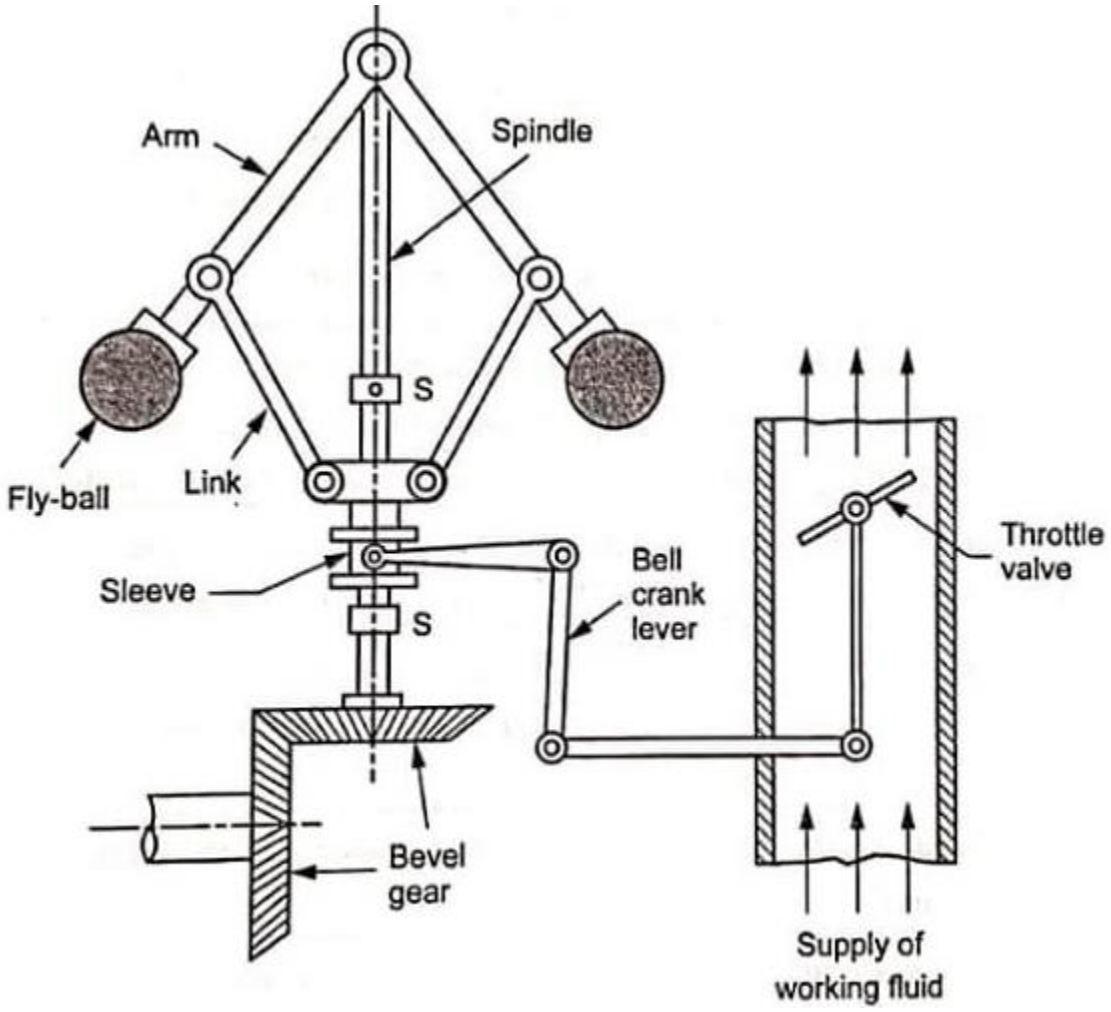
We know that angle of wrap, θ = 360 X ¾ = 270 X π/180 = 4.713 Rad. — 02

$$\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.25x4.713} = 3.253$$ -- 1

We know that braking torque (TB),

$T_B = (T_1 - T_2)\ r$

$225 = (T_1 - T_2)\ 0.225$

		$(T_1 - T_2) = 225/0.225 = 1000N$ ---------- 2 From equations **1** and **2,** we have $T_1 = 1444$ N; and $T_2 = 444$ N Now taking moments about the fulcrum O, we have $P \times l = T_2.b$ Or $P \times 0.5 = 444 \times 0.1 = 44.4$ $P = 44.4 / 0.5$ **P = 88.8 N**	01 01
	c)	 **Working** The centrifugal governors are based on the balancing of centrifugal force on the rotating balls by an equal and opposite radial force. When the load on the engine decreases, the engine and the governor speed increases. This increases the centrifugal force acting on the balls and the balls move radially outwards. Therefore the sleeve rises upwards. This upward movement of the sleeve reduces the supply of the working fluid and hence the speed is decreased. Thus the engine speed falls and comes near about the mean speed.	02+01 label 0

		Similarly, when the load increases, the speed of the engine and the governor decreases. This results in the decrease of centrifugal force on the balls. Hence the balls move inwards and the sleeve moves downwards. The downward movement of the sleeve increases the supply of the working fluid and hence the speed is increased. Thus the engine speed rises and comes near about the mean speed.	
		END	