Zeal Education Society's

ZEAL POLYTECHNIC, PUNE.

NARHE | PUNE -41 | INDIA

SECOND YEAR (SY)

DIPLOMA IN MECHANICAL ENGINEERING

SCHEME: I SEMESTER: IV

NAME OF SUBJECT: Theory of Machines

Subject Code: 22438

MSBTE QUESTION PAPERS & MODEL ANSWERS

1. **MSBTE SUMMER-19 EXAMINATION**
2. **MSBTE WINTER-19 EXAMINATION**

22438

11920

3 Hours / 70 Marks Seat No. | | | | | | | | |

Instructions – (1) All Questions are *Compulsory.*

(2) Answer each next main Question on a new page.

(3) Illustrate your answers with neat sketches wherever necessary.

(4) Figure to the right indicate full marks.

(5) Use of Non-Programmable Electronic Pocket Calculator is permissible.

(6) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

Marks

1. Attempt any FIVE of the following: **10**

a) Identify Kinematic pairs and named it. Refer Fig. No. 1

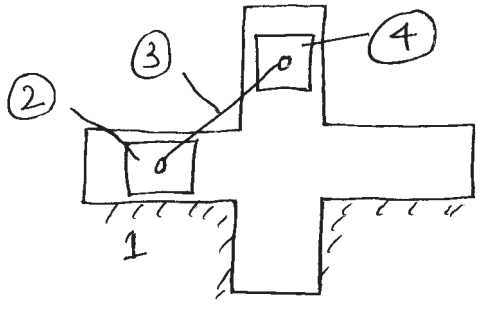


Fig. No. 1

b) Define completely constrained motion and successfully constrained motion.

c) State the necessity of Acceleration diagram of a mechanism.

d) State the reason of using roller follower over kinfe edge follower.

e) Define base circle and pressure angle.

f) Draw a neat sketch of internal expanding shoe brake and lable it.

g) State the adverse effect of imbalance on rotating element of machine.

P.T.O.

Marks

2. Attempt any THREE of the following: **12**

a) Draw a neat sketch of crank and slotted lever quick return mechanism of shaper. Write formula of cutting ratio.

b) Compare Belt Drive and Chain Drive (four points)

c) Explain with neat sketch method of drawing displacement diagram for SHM of follower.

d) An I.C. Engine developing 10 kW of power is to be transmitted to a machine by flat leather belt. A 0.8 m diameter pulley is fitted on engine shaft and rotates at 300 rpm. The angle of lap is 175^{o} and coefficient of friction in belt and pulley is 0.25. Determine tensions in the belt.

3. Attempt any THREE of the following: **12**

a) Explain the working of Scotch Yoke mechanism with neat sketch.

b) Differentiate between mechanism and machine.

c) Write any two functions and applications of clutch.

d) Write the classification of follower

(i) As per shape

(ii) As per motion.

Draw sketch of any one follower.

e) Draw and explain the turning moment diagram of 4-stroke I.C. Engine.

4. Attempt any TWO of the following: **12**

a) Define following terms

(i) Kinematic link
(ii) Kinematic pair
(iii) Kinematic chain
(iv) Mechanism
(v) Machine
(vi) Inversion

Marks

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

c) A cam operates a roller follower, axis passing through the axis of cam.

The specifications are

Minimum radius of cam = 25 mm

Lift of follower = 30 mm

Diameter of roller = 15 mm

Angle of lift = 120^o with SHM

Outer dwell angle = 30^o

Angle of return = 150^o with uniform

acceleration and retardation.

Draw the cam profile.

5. Attempt any TWO of the following: **12**

a) Explain with neat sketch compound type Gear Train. Derive the equation for velocity ratio of gear train. Write it's application.

b) In reciprocating engine the crank is 250 mm long and connecting rod is 1000 mm long. The crank rotates at 150 rpm. Find velocity and acceleration of piston. And angular velocity and angular acceleration of connecting rod when the crank makes an angle of 30^o to IDC. Use analytical method.

c) Three masses m_1, m_2 and m_3 are of 100N, 200N and 150N respectively. The corresponding radii are 0.3 m, 0.15 m and 0.25 m respectively. Angles between masses m_1 and m_2 is 45^o and between m_2 and m_3 is 75^o and between m_3 and m_1 is 240^o. Determine graphically the position and magnitude of the balance mass required if the radius of rotation is 0.2 m.

Marks

6. Attempt any TWO of the following: **12**

a) Two Pulleys one 450 mm diameter and other 200 mm diameter are on parallel shaft is 1.95 apart and are connected by cross-belt drive. Find the length of belt required and angle of contact between the belt and each pulley.

What power can be transmitted by belt, when the larger pulley rotates at 200 rpm, If maximum permissible tension in the belt is 1000 N, $\mu = 0.25$

b) Draw the sketch of multiplate clutch and describe its construction and working.

c) Compare flywheel with Governer.

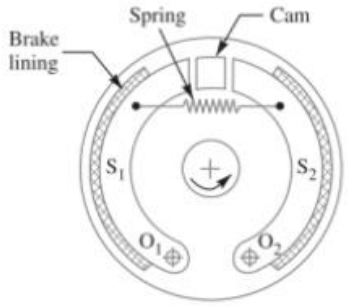
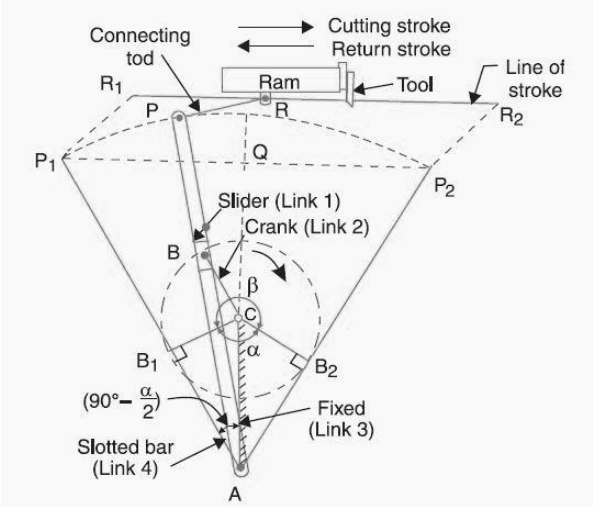
WINTER – 19 EXAMINATION

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

Important Instructions to examiners:

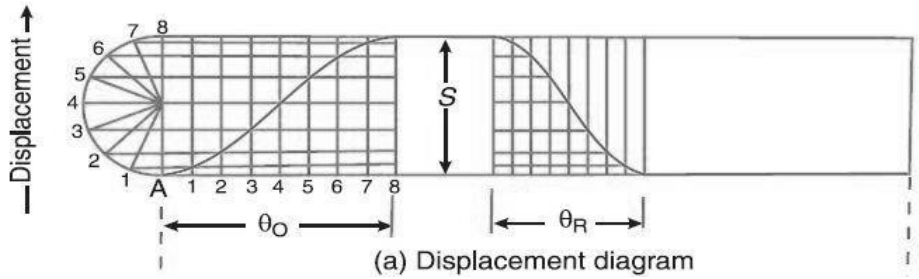
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

Q. No.	Sub Q. N.	Answer	Marking Scheme
Q.1	a)	1) Link 1 and 2 -- Sliding Pair 2) Link 2 and 3 -- Turning Pair 3) Link 3 and 4 -- Turning Pair 4) Link 4 and 1 -- Sliding pair	1/2 Marks Each Pair
	b)	**1)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. **2)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.	1 Mark Each
	c)	1) Acceleration diagram is important in mechanism , because acceleration is directly related to force. $F = m*a$ 2) By calculating acceleration, we calculate inertia force acting on different links. 3) Design of machine parts rotating at higher speed becomes safe.	2 Marks
	d)	1) Roller follower has less wear and tear than knife edge follower. 2) Power required for driving the cam is less due to less frictional force between cam and follower.	2 Marks
	e)	1) Base circle. It is the smallest circle that can be drawn to the cam profile. 2) Pressure angle. It is the angle between the direction of the follower motion and a normal to the pitch curve.	1 Mark Each

	f)	 (a) Internal expanding brake.	1 Mark diagram 1 Mark labeling
	g)	1) The dynamic forces are set up and these forces increase the loads on bearings and stresses in the various members. 2) Produce unpleasant noise and dangerous vibrations.	1 Mark Each
Q.2	a)	<u>Crank and slotted Quick Return Mechanism for shaper</u>  <u>Formula of cutting ratio</u> $\frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{\beta}{\alpha} = \frac{\beta}{360° - \beta}$ or $\frac{360° - \alpha}{\alpha}$	3 Marks Diagram 1 Mark Formula
	b)		Any Four Points 1 Mark Each

Particulars	Belt drive	Chain drive
Slip	Slip may occur	No slip (Positive drive)
Use	For low Velocity Ratio	For moderate Velocity Ratio
Suitability	For large centre distance	For moderate centre distance
Space requires	Large	Moderate
Lubrication	Not required	Require
Installation cost	Less	Moderate
Example	Floor Mill, Compressor, Conveyors	Bicycle, Automobile

c)



(a) Displacement diagram

2 Marks Diagram

The displacement diagram is drawn as follows for SHM of follower :

1. Draw a semi-circle on the follower stroke as diameter.
2. Divide the semi-circle into any number of even equal parts (say eight).
3. Divide the angular displacements of the cam during out stroke and return stroke into the same number of equal parts.
4. The displacement diagram is obtained by projecting the points as shown in Figure

2 Marks Method

d)

Given Data :-

Power (P) = 10 kW = 10×10^3 watts.

Diameter of pulley (D) = 0.8 m = 800 mm

Speed of pulley (N) = 300 rpm

Angle of lap (θ) = $170^\circ = 175 \times \frac{\pi}{180} = 3.05$ rad

Co-efficient of friction (μ) = 0.25

Find T_1 = Tight side tension = ?

T_2 = slack side tension = ?

Solution :-

Velocity of Belt (v) = $\frac{\pi DN}{60}$

$\therefore v = \frac{\pi \times 0.8 \times 300}{60}$

$v = 12.56$ m/sec — 1 Mark

Power transmitted by belt (P)

$\therefore P = (T_1 - T_2) \times v$

$10 \times 10^3 = (T_1 - T_2) \times 12.56$

$\therefore T_1 - T_2 = 796.17$ ..... (1) — 1 Mark

Belt tension Ratio

$\frac{T_1}{T_2} = e^{\mu\theta} = e^{(0.25 \times 3.05)}$

$\therefore \frac{T_1}{T_2} = 2.14$ $\therefore T_1 = 2.14\, T_2$ — 1 Mark

put value of T_1 in eqn (1)

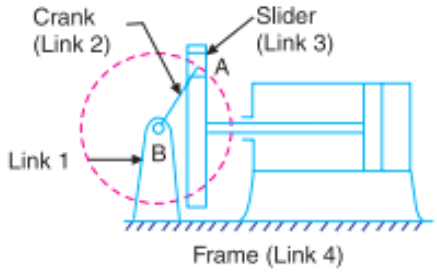
$2.14\, T_2 - T_2 = 796.17$

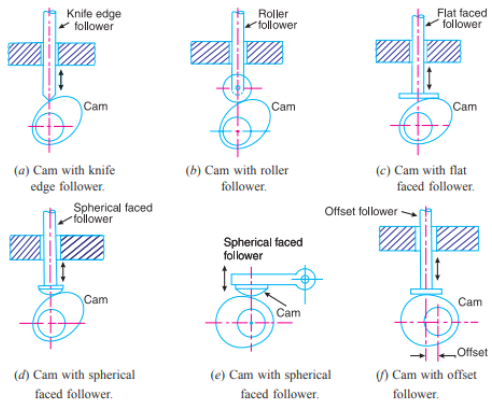
$\therefore T_2 = 698.3$ N.

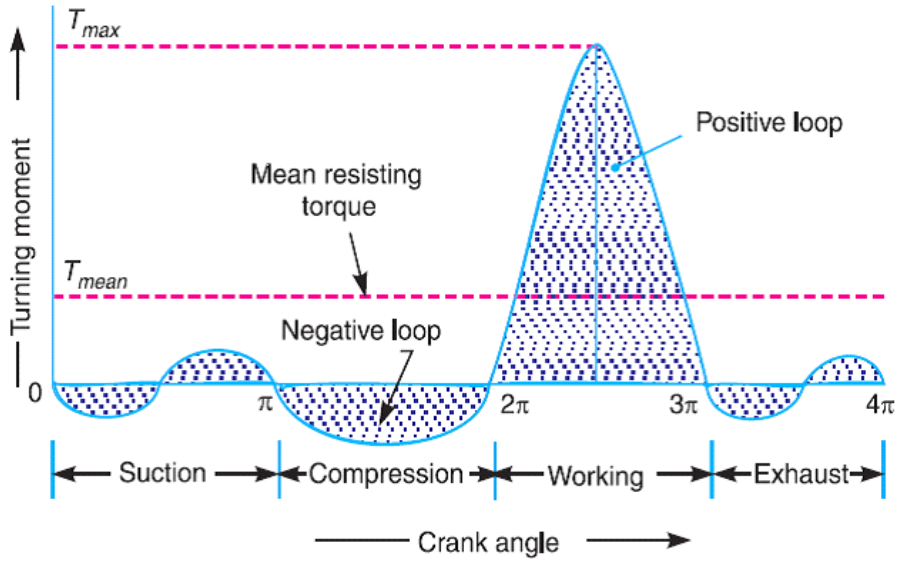
$\therefore T_1 = 2.14 \times 698.3$ — 1 Mark.

$T_1 = 1494.3$ N

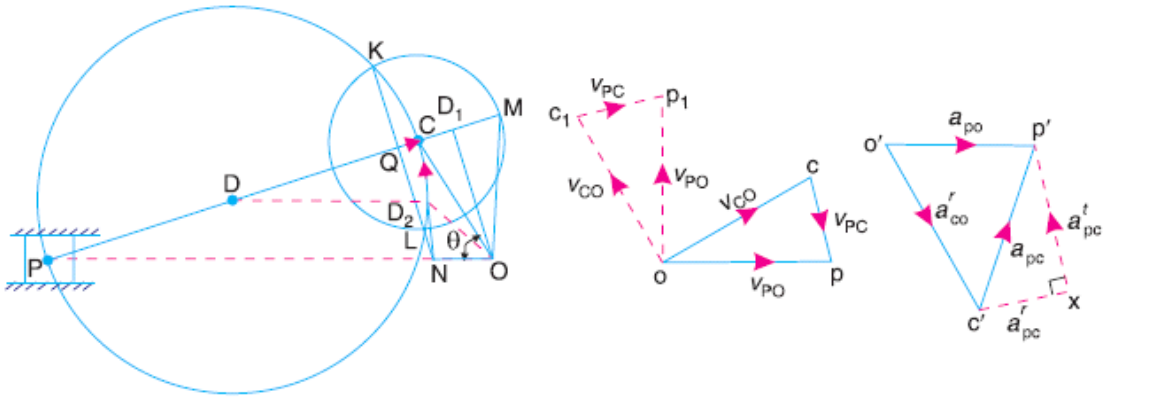
$\therefore$ Tight side Tension (T_1) = 1494.3 N, slack side Tension (T_2) = 698.3 N

Q.3	a)	**Scotch yoke mechanism.** This mechanism is used for converting rotary motion into a reciprocating motion. The inversion is obtained by fixing either the link 1 or link 3. In Fig. link 1 is fixed. In this mechanism, when the link 2 (which corresponds to crank) rotates about B as centre, the link 4 (which corresponds to a frame) reciprocates. The fixed link 1 guides the frame  	2 M 2M **Sketch**
	b)	**Difference between Mechanism & machine** Sr.No | Mechanism | Machine 1 | Primary function is used to transmit or modify the motion. | Primary function is to obtain the mechanical advantage 2 | It is not used to transmit the force. | It is used transmit the force 3 | A mechanism is a single system to transfer the motion | A machine has one or more mechanism to perform the desired function. 4 | eg.i) In watch, energy stored on winding the spring is used to move hands. ii) An indicator is used to draw P-V diagram of engine | eg. i) Shaper receives mechanical power which is used to suitably convert to do work of cutting the metal. ii) A hoist is machine to lift the loads.	1M each
	c)	**Functions of clutch:** i) A clutch is a device used to transmit rotary motion of one shaft to the other shaft when desired. ii) A clutch is a device used for engaging and disengaging the engine crank shaft instantaneously when desired by the driver. iii) A clutch is a device used to deliver power to machines partially or fully loaded. **Applications:** i) Single plate clutch: Heavy vehicles, four-wheeler such as car, truck, bus ii) Multi plate clutch: Two wheelers, mopeds, scooters, bikes iii) Cone clutch: Machine tools, automobiles, press work iv) Centrifugal clutch: mopeds, Luna	2M **(ANY 2 functions)** 2M **(ANY 2 applications)**

	d)	Classification of follower: i) As per shape: • Knife-edge follower: When the contacting end of the follower has a sharp knife edge, it is called a knife edge follower. • Roller follower: When the contacting end of the follower is a roller, it is called a roller follower. • 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. • Spherical follower: When the contacting end of the follower is of spherical shape, it is called a spherical faced follower. ii) As per motion: • Reciprocating or translating follower: When the follower reciprocates in guides as the cam rotates uniformly, it is known as reciprocating or translating follower. • 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. **(Sketch any one 01 marks)** 	03 M for classification 01 M Sketch
	e)	A turning moment diagram for a four stroke cycle internal combustion engine is shown. We know that in a four stroke cycle internal combustion engine, there is one working stroke after the crank has turned through two revolutions, *i.e.* 720° (or 4 ð radians). Turning moment diagram for a four stroke cycle internal combustion engine. Since the pressure inside the engine cylinder is less than the atmospheric pressure during the suction stroke, therefore a negative loop is formed as shown in Fig. During the compression stroke, the work is done on the gases, therefore a higher negative loop is obtained. During the expansion or working stroke, the fuel burns and the gases expand, therefore a large positive loop is obtained. In this stroke, the work is done by the gases. During exhaust stroke, the work is done on the gases, therefore a negative loop is formed. It may be noted that the effect of the inertia forces on the piston is taken into account in Fig	2M

			2M
Q.4	a)	(i) **Kinematic link**: Each part of a machine, which moves relative to some other part, is known as a kinematic link. (ii) **Kinematic pair**: 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. (iii) **Kinematic chain**: 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. (iv) **Mechanism**: When one of the links of a kinematic chain is fixed, the chain is known as mechanism. It may be used for transmitting or transforming motion e.g. engine indicators, typewriter etc. (v) **Machine**: A machine is a device which receives energy and transforms it into some useful work. (vi) **Inversion:** When one of 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.	1M Each
	b)	Let *OC* be the crank and *PC* the connecting rod of a reciprocating steam engine, as shown in Fig. Let the crank makes an angle θ with the line of stroke *PO* and rotates with uniform angular velocity ω rad/s in a clockwise direction. The Klien's velocity and acceleration diagrams are drawn as discussed below:	

3M



(*a*) Klien's acceleration diagram. (*b*) Velocity diagram. (*c*) Acceleration diagram.

Klien's construction

Klien's velocity diagram 3M

First of all, draw *OM* perpendicular to *OP*; such that it intersects the line *PC* produced at *M*. The triangle *OCM* is known as Klien's velocity diagram. In this triangle *OCM*, *OM* may be regarded as a line perpendicular to *PO*, *CM* may be regarded as a line parallel to *PC*, and ...(_It is the same line.) *CO* may be regarded as a line parallel to *CO*. The velocity diagram for given configuration is a triangle *ocp*

as shown in Fig. If this triangle is revolved through 90°, it will be a triangle oc_1p_1, in which oc_1 represents v_{CO} (*i.e.* velocity of *C* with respect to *O* or velocity of crank pin *C*) and is paralel to *OC*,

op_1 represents v_{PO} (*i.e.* velocity of *P* with respect to *O* or velocity of cross-head or piston *P*) and is perpendicular to *OP*, and

c_1p_1 represents v_{PC} (*i.e.* velocity of *P* with respect to *C*) and is parallel to *CP*.

the triangles oc_1p_1 and *OCM* are similar. Therefore,

$$\frac{oc_1}{OC} = \frac{op_1}{OM} = \frac{c_1p_1}{CM} = \omega \text{ (a constant)}$$

or
$$\frac{v_{CO}}{OC} = \frac{v_{PO}}{OM} = \frac{v_{PC}}{CM} = \omega$$

$\therefore$ $v_{CO} = \omega \times OC$; $v_{PO} = \omega \times OM$, and $v_{PC} = \omega \times CM$

Thus, we see that by drawing the Klien's velocity diagram, the velocities of various points may be obtained without drawing a separate velocity diagram.

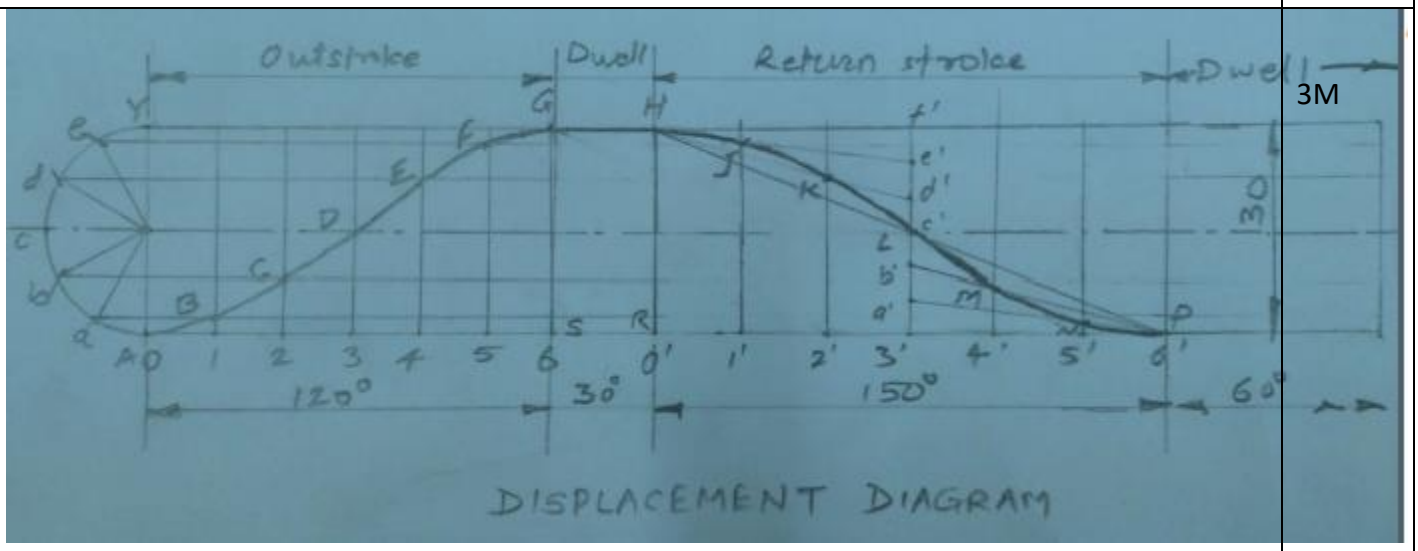
Klien's acceleration diagram

The Klien's acceleration dia- gram is drawn as discussed below:

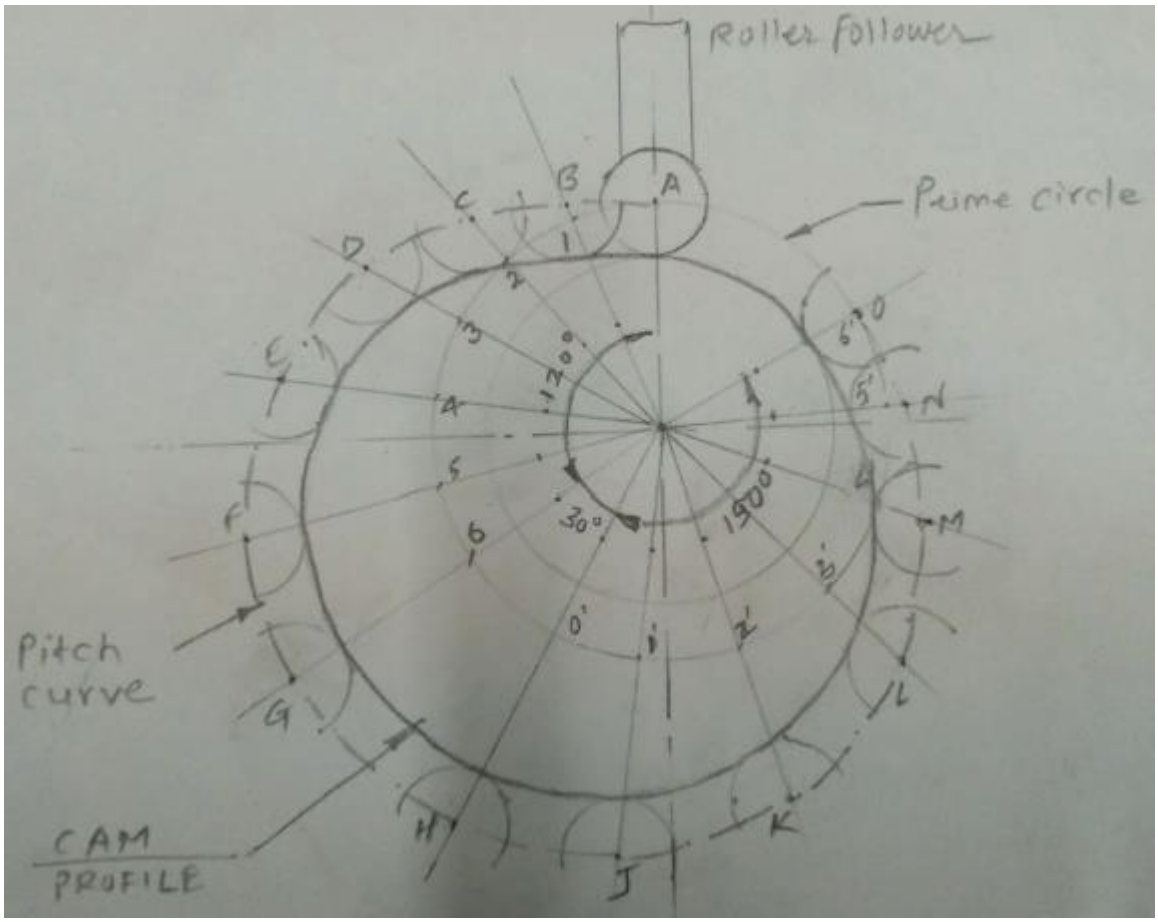
1. First of all, draw a circle with *C* as centre and *CM* as radius.
2. Draw another circle with *PC* as diameter. Let this circle intersect the previous circle at *K* and *L*.
3. Join *KL* and produce it to intersect *PO* at *N*. Let *KL* intersect *PC* at *Q*. This forms the quadrilateral *CQNO*, which is known as *Klien's acceleration diagram*.

Acceleration of piston, $\alpha_p = \omega^2$ ON

c)


Outstroke
Dwell
Return stroke
Dwell
120°
30°
150°
60°
DISPLACEMENT DIAGRAM

3M


Roller follower
Prime circle
Pitch curve
CAM PROFILE

3M

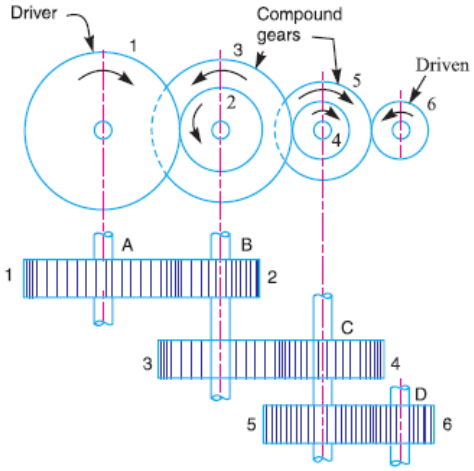
Q.5 a)

Compound Gear Train:

When there are more than one gear on a shaft, as shown in Fig. , it is called a ***compound train of gear*. I**n a simple train of gears do not affect the speed ratio of the system. But these gears are useful in bridging over the space between the driver and the driven. 2M

Gear trains inside a mechanical watch

But whenever the distance between the driver and the driven or follower has to be bridged over by intermediate gears and at the same time a great (or much less) speed ratio is required, then the advantage of intermediate gears is intensified by providing compound gears on intermediate shafts. In this case, each intermediate shaft has two gears rigidly fixed to it so that they may have the same speed. One of these two gears meshes with the driver and the other with the driven or follower attached to the next shaft as shown in Fig. 1M



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*. 2M

Let $N1$ = Speed of driving gear 1,
$T1$ = Number of teeth on driving gear 1,
$N2$,$N3$ ..., $N6$ = Speed of respective gears in r.p.m., and
$T2$,$T3$..., $T6$ = Number of teeth on respective gears.
Since gear 1 is in mesh with gear 2, therefore its speed ratio is

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

Similarly, for gears 3 and 4, speed ratio is

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

and for gears 5 and 6, speed ratio is

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

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

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

1M

Applications – 1. Automobile gear box 2. Lathe machines

3. Clocks/ watches 4. Electro mechanical meter

b)

Given : r = **0.25** l = 1 m ; N = **150** r.p.m. or $\omega = \pi \times 150/60 =$ **7.85** rad/s; θ = **30°**

Velocity of the piston — 1M

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

$$n = l/r = 4$$

∴ Velocity of the piston,

$$v_p = \omega r\left(\sin\theta + \frac{\sin 2\theta}{2n}\right)$$

$$= 7.85 \times 0.25\left(\sin 30° + \frac{\sin 60°}{2 \times 4}\right) \text{m/s} \quad \text{— 2M}$$

$$= 1.19 \text{ m/s}$$

Acceleration of the piston

We know that acceleration of piston, — 1M

$$a_p = \omega^2 r\left(\cos\theta + \frac{\cos 2\theta}{n}\right)$$

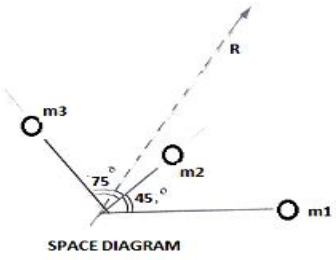
$$= (7.85)^2 \times 0.25\left(\cos 30° + \frac{\cos 60°}{5}\right) \text{m/s}^2 \quad \text{— 2M}$$

$$= 14.88 \text{ m/s}^2$$

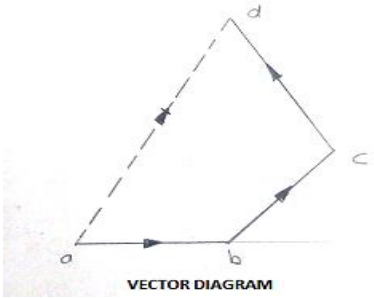
c)

Given data m_1 = 100N, m_2 = 200 N , m_3 = 150 N , r_1 = 0.3m , r_2 = 0.15 m, r_3 = 0.25m

Radius of rotation = r= 0.2m



SPACE DIAGRAM — 1M



VECTOR DIAGRAM — 3M

Balancing force is equal to resultant force

So, m x r = 63 — 2M

m x 0.2 = 63

m = 315 N

Measurement θ = 60^0

Q.6	a)	Given : $d_1 = 450$ mm $= 0.45$ m or $r_1 = 0.225$ m ; $d_2 = 200$ mm $= 0.2$ m or $r_2 = 0.1$ m ; $x = 1.95$ m ; $N_1 = 200$ r.p.m. ; $T_1 = 1$ kN $= 1000$ N ; $\mu = 0.25$ We know that speed of the belt, $v = \frac{\pi d_1 . N_1}{60} = \frac{\pi \times 0.45 \times 200}{60} = 4.714$ m/s ***Length of the belt*** We know that length of the crossed belt, $L = \pi(r_1 + r_2) + 2x + \frac{(r_1 + r_2)^2}{x}$ $= \pi(0.225 + 0.1) + 2 \times 1.95 + \frac{(0.225 + 0.1)^2}{1.95} = 4.975$m **Ans.** ***Angle of contact between the belt and each pulley*** Let θ = Angle of contact between the belt and each pulley. We know that for a crossed belt drive, $\sin\alpha = \frac{r_1 + r_2}{x} = \frac{0.225 + 0.1}{1.95} = 0.1667$ or $\alpha = 9.6°$ $\therefore \theta = 180° + 2\alpha = 180° + 2 \times 9.6° = 199.2°$ $= 199.2 \times \frac{\pi}{180} = 3.477$ rad **Ans.** We know that $2.3 \log\left(\frac{T_1}{T_2}\right) = \mu . \theta = 0.25 \times 3.477 = 0.8692$ $\log\left(\frac{T_1}{T_2}\right) = \frac{0.8692}{2.3} = 0.378$ or $\frac{T_1}{T_2} = 2.387$ ...(Taking antilog of 0.378) $\therefore T_2 = \frac{T_1}{2.387} = \frac{1000}{2.387} = 419$ N We know that power transmitted, $P = (T_1 - T_2) v = (1000 - 419)\ 4.714 = 2740$ W $= 2.74$ kW	1M 1M 1M 1M 1M 1M
	b)	Multi – Plate clutch consists of a number of clutch plates instead of only one clutch plate like in the Single plate clutch. Friction surface also increased because of a number of clutch plates. Because of number of friction surfaces, the capacity of the clutch to transmit torque is also increased. The plates are alternately fitted to the engine crankshaft and gearbox shaft. They are firmly pressed by strong coil springs and assembled in a drum type casing. Each of the alternate clutch plate slides on the grooves on the flywheel and the other slides on splines on the pressure plate. Thus, each alternate clutch plate has inner and outer splines. A multiple disc clutch, as shown in Fig., may be used when a large torque is to be transmitted. The inside discs (usually of steel) are fastened to the driven shaft to permit axial motion (except for the last disc). The outside discs (usually of bronze) are held by bolts and are fastened to the	2M 2M

housing which is keyed to the driving shaft. The multiple disc clutches are extensively used in motor cars, machine tools etc.

Let n_1 = Number of discs on the driving shaft, and n_2 = Number of discs on the driven shaft.

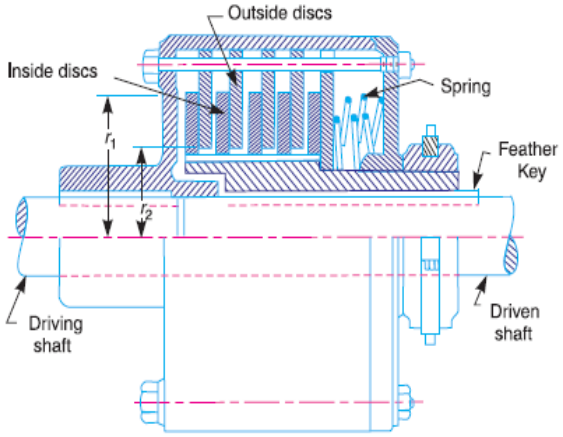
Number of pairs of contact surfaces,

$n = n_1 + n_2 - 1$

and total frictional torque acting on the friction surfaces or on the clutch,

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

where R = Mean radius of the friction surfaces



2M

c) **Difference between Flywheel and Governor**

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

1 M each

22438

21819

3 Hours / 70 Marks Seat No. | | | | | | | | |

Instructions – (1) All Questions are *Compulsory.*

(2) Answer each next main Question on a new page.

(3) Illustrate your answers with neat sketches wherever necessary.

(4) Figures to the right indicate full marks.

(5) Assume suitable data, if necessary.

(6) Use of Non-programmable Electronic Pocket Calculator is permissible.

(7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

(8) Use of steam tables, logarithmic, Mollier's chart is permitted.

Marks

1. Attempt any FIVE of the following: **10**

a) Define term 'kinetics'.

b) List different types of 'kinematic pair'.

c) State the relation between relative velocity and motion of link in mechanism.

d) List any four applications of 'cam' and 'follower'.

e) Define the term 'Dwell' w.r.t cam profile.

f) State the functions of clutches.

g) Define coefficient of fluctuation of energy.

Marks

2. Attempt any THREE of the following: **12**

a) Draw neat diagram of 'scotch yoke mechanism'? Explain its constructional features in brief.

b) Explain the term:

(i) Slip

(ii) Creep

c) Draw the following displacement diagram for follower:

(i) S.H.M

(ii) Uniform acceleration and decelaration

d) Differentiate between belt drive and gear drive.

3. Attempt any THREE of the following: **12**

a) Draw a neat sketch of 'Locomotive coupler' mechanism? Explain its working in brief.

b) Name the suitable mechanism to be used for following applications:

(i) Lifting water from well

(ii) Connecting misaligned shafts

(iii) Converting rotary motion into reciprocating motion

(iv) Maintain constant relative motion between two rotary elements

c) Explain the construction of 'Disc brake' with neat sketch.

d) Draw basic 'cam-follower' diagram showing its terminology (Mini four terminology).

e) State the necessity of Balancing. List different types of Balancing methods.

Marks

4. Attempt any TWO of the following: **12**

a) Draw the labelled diagram of Crank and slotted lever Quick Return Mechanism.

b) A crank of slider crank mechanism rotates clock wise at constant speed of 300 rpm. The crank is 150 mm and connecting rod is 600 mm long.

Determine:

(i) Linear velocity of the midpoint of connecting rod.

(ii) Angular acceleration of connecting rod at a crank angle of 45° from inner dead centre position.

c) Draw the profile of cam operating a knife edged follower from following data:

(i) Follower to move outwards through 40mm during 60° of cam rotation.

(ii) Follower dwell for next 45°.

(iii) Follower to return to its original position during next 90°.

(iv) Follower to dwell for rest of the rotation. The displacement of follower is to take place with simple harmonic motion during both outward and return strokes. The least radius of cam is 50 mm. If the cam rotates at 300 rpm.

5. Attempt any TWO of the following: **12**

a) Two parallel shafts whose centre lines are 4.8 m apart are connected by open belt drive. The diameter of larger pulley is 1.5 m and that of smaller pulley 1 m. The initial tension in the belt when stationary is 3 kN. The mass of the belt is 1.5 kg/m length. The coeff of friction between belt and pulley is 0.3. Taking centrifugal tension in to account. Calculate power transmitted when smaller pulley rotates at 400 rpm.

Marks

b) A 4-bar mechanism has following dimensions:

l(DA)= 300 mm l(CB) = l(AB) = 360 mm

l(DC) = 600 mm. The link 'DC' is fixed. The angle ADC is 60°

The driving link 'DA' rotates at a speed of 100 rpm clockwise and constant driving torque is 50 N.M. Calculate the Velocity of point 'B' and angular velocity of driven link 'CB'.

c) Explain the following terms of centrifugal governor with neat sketch:

(i) Height of governor

(ii) Equilibrium speed

(iii) Sleeve lift

6. Attempt any <u>TWO</u> of the following: **12**

a) Two pulleys one 450 mm diameter and the other 200 mm diameter are on parallel shafts 1.95 m apart and are connected by a crossed belt. Find the length of belt required and angle of contact between belt and each pulley.

Estimate the power transmitted by belt when the larger pulley rotates at 200 rpm. If the maximum tension in the belt is 1 kN and coeff of friction between belt and pulley is 0.25.

b) Draw the constructional details diagram of centrifugal clutch. Explain its working principle

c) The weights of four masses A, B, C, D are 200 kg, 300 kg, 240 kg, 260 kg respectively. The corresponding radii of rotation are 200 mm, 150 mm, 250 mm and 300 mm respectively and the angle between successive masses are 45°, 75° and 135°. Find the position and magnitude of the balance weight required if its radius of rotation is 200 mm.

SUMMER – 2019 EXAMINATIONS

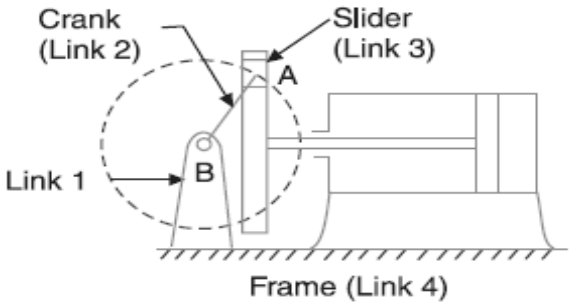
Subject Name: Theory of Machines **Model Answer** **Subject Code:** **22438**

Important Instructions to examiners:

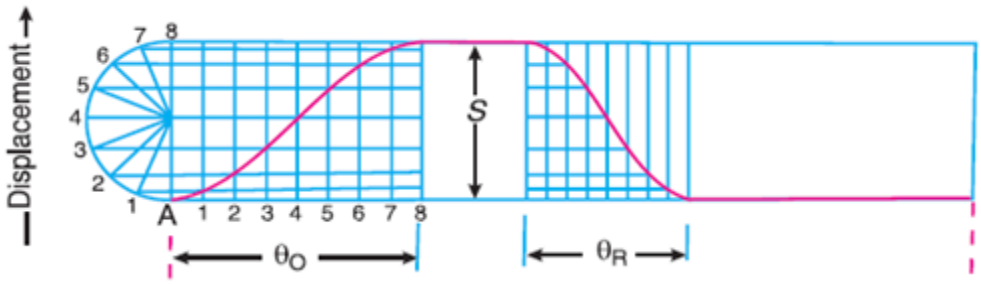
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

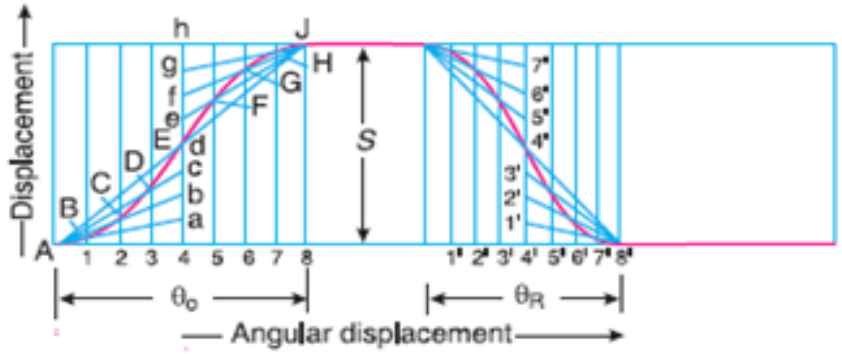
Q. No.	Sub Q. N.	Answer	Marking Scheme
1		**Attempt any FIVE of the following: (2 x 5)**	**10**
1	(a)	**Define term 'Kinetics'.**	**02**
	Ans.	**(02 Mark for the appropriate significance of Kinetics)** **Definition of Kinetics:** It is that branch of Theory of Machines which deals with the inertia forces which arise from the combined effect of the mass and motion of the machine parts.	**02**
1	(b)	**List different types of 'Kinematic Pair'.**	**02**
		(Classification on any 2 basis with sub types, 01 Mark each) **Types of Kinematic pairs:** **[1] According to the type of relative motion between the elements:** (a) Sliding pair. (b) Turning pair. (c) Rolling pair. (d) Screw pair. (e) Spherical pair. **[2] According to the type of contact between the elements:** (a) Lower pair. (b) Higher pair. **[3] According to the type of closure:** (a) Self closed pair. (b) Force - closed pair. **[4] According to Constrained Motion:** (a) Incompletely Constrained (b) Completely Constrained (c) Successfully Constrained	**02**

Q. No.	Sub Q. N.	Answer	Marking Scheme
1	(c)	**State the relation between relative velocity and motion of link in mechanism.**	02
	Ans.	**Relation between Relative Velocity and motion of link in mechanism:** The relative velocity is the velocity of any point with respect to any other some point on the same link. Let, V be the relative velocity of one end w.r.t. other end of link in m/sec ω be the angular motion in rad/sec & r as the length of same link in meter Then, the relation is expressed as; $V = r \times \omega$ m/sec	02
1	(d)	**List any four applications of 'cam' and 'follower'.**	02
	Ans.	**(Any four applications, ½ Marks for each)** **Applications of Cam and Follower:** [1] Operating the inlet and exhaust valves of internal combustion engines [2] Used in Automatic attachment of machineries, paper cutting machines [3] Used in Spinning and weaving textile machineries. [4] Used in Feed mechanism of automatic lathes etc. [5] Used in Diesel Fuel Pumps. [6] Used in printing control mechanism [7] Used in wall clock [8] Used in feed mechanism of automatic lathe.	02
1	(e)	**Define the term 'Dwell' w.r.t. cam profile.**	02
	Ans.	**Definition of Dwell:** It is duration of cam rotation during which there is no motion to the follower. That means during dwell period though cam rotates but follower remains stationary. **OR** When the follower is not moving upward and downward even when the cam rotates is called as dwell.	02
1	(f)	**State the functions of clutches.**	02
	Ans.	**Functions of Clutches:** [1] To engage and disengage output shaft with the engine shaft as and when required. [2] To engage shafts very smoothly without much slipping of friction surfaces. [3] To transmit power from engine shaft to output shaft without loss. [4] To engage the shafts smoothly without noise and jerk	02

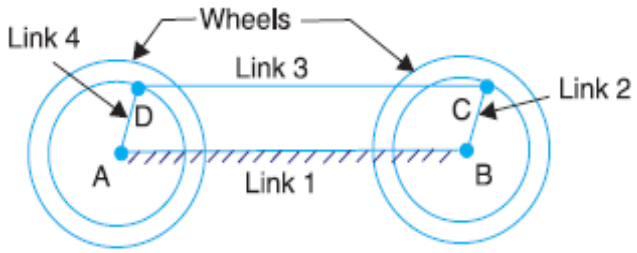
Q. No.	Sub Q. N.	Answer	Marking Scheme
1	(g)	**Define coefficient of fluctuation of energy.**	**02**
	Ans.	**Definition of Coefficient of Fluctuation of Energy:** It may be defined as the ratio of the maximum fluctuation of energy to the work done per cycle. Mathematically it is expressed as; $C_E = \frac{\text{Maximum fluctuation of energy}}{\text{Work done per cycle}}$ The work done per cycle (in N-m or joules)	**02**
2		**Attempt any THREE of the following: (3 x 4)**	**12**
2	(a)	**Draw a neat diagram of 'Scotch Yoke Mechanism'. Explain its constructional features in brief.**	**04**
		 Scotch yoke mechanism. **Constructional Features of Scotch Yoke Mechanism:** [1] In this mechanism, two sliding pairs and two turning pairs are used. So it is an inversion of Double Slider Crank Chain Mechanism. [2] It consists of following types of links with relative motion as mentioned below; Link 1 (B) – Fixed Link – Guide the Frame Link 2 – Crank – Turning Motion – Rotates about Point B in Link 1 Link 3 - Slider -Sliding Motion Link 4 – Fixed Link – Frame – Reciprocating Motion [3] The inversion is obtained by fixing either the Link 1 or Link 3.	**02 Marks for Labeled Sketch** **02 Marks for Constructional Features**

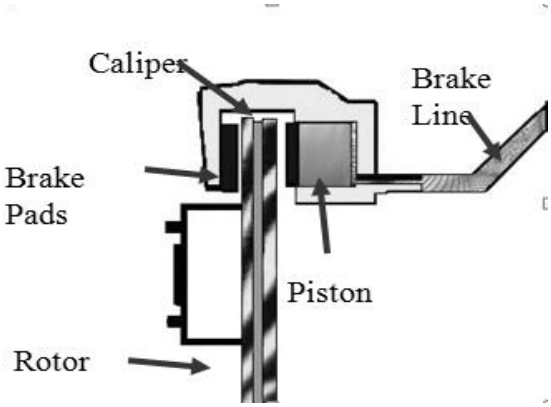
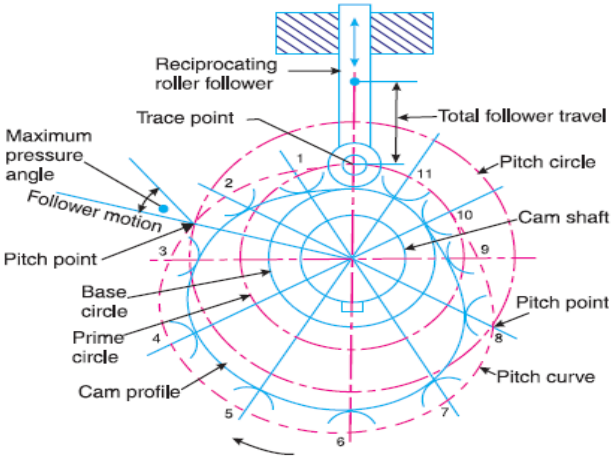
Q. No.	Sub Q. N.	Answer	Marking Scheme
2	(a)	**Draw a neat diagram of 'Scotch Yoke Mechanism'. Explain its constructional features in brief.**	**04**
	Ans.	[4] When the link 2 (which corresponds to crank) rotates about *B* as centre, the link 4 (which corresponds to a frame) reciprocates. It is used for converting rotary motion into a reciprocating motion.	
2	(b)	**Explain the term: (i) Slip (ii) Creep**	**04**
	Ans.	**Slip:** The forward motion of the driver without carrying the belt with it or forward motion of the belt without carrying the driven pulley with it, is called slip of the belt. Slip reduces velocity ratio and also power transmission capacity of the belt drive. Less slip in the belt drive is desirable.	**01**
		OR When belt is transmitted power from driver to driven pulley, there is a loss of motion due to insufficient frictional grip and therefore the speed of driven pulley is less than driver pulley. This is known as ***Slip of the belt*** & generally expressed in %	
		Slip of Belt by neglecting thickness of belt is expressed as below; $$\frac{N_2}{N_1} = \frac{d_1}{d_2}\left(1 - \frac{s}{100}\right)$$	
		Creep: When the belt passes from the slack side to the tight side, a certain portion of the belt extends and it contracts again when the belt passes from the tight side to slack side. Due to these changes of length, there is a relative motion between the belt and the pulley surfaces. This relative motion is termed as creep.	**01**
		Creep reduces velocity ratio and also power transmission capacity of the belt drive. Less creep in the belt drive is desirable.	**01**
		Creep of Belt is expressed as below; $$\frac{N_2}{N_1} = \frac{d_1}{d_2} \times \frac{E + \sqrt{\sigma_2}}{E + \sqrt{\sigma_1}}$$ σ_1 and σ_2 = Stress in the belt on the tight and slack side respectively, and E = Young's modulus for the material of the belt.	**01**

<table>
<tr><th>Q. No.</th><th>Sub Q. N.</th><th>Answer</th><th>Marking Scheme</th></tr>
<tr><td>2</td><td>(c)</td><td>Draw the following displacement diagram for follower:
(i) SHM (ii) Uniform acceleration and deceleration</td><td>04</td></tr>
<tr><td></td><td>Ans.</td><td>Displacement Diagram for Simple Harmonic Motion (SHM):
 

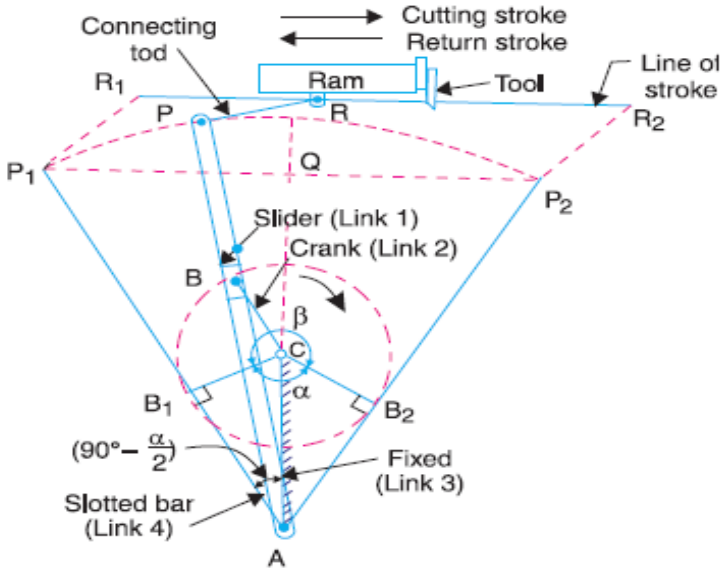
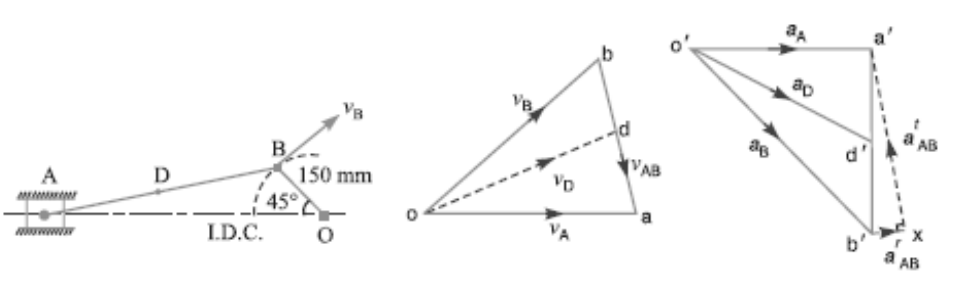
Angular Displacement
Displacement Diagram for Uniform Acceleration and Deceleration:
 
</td><td>02

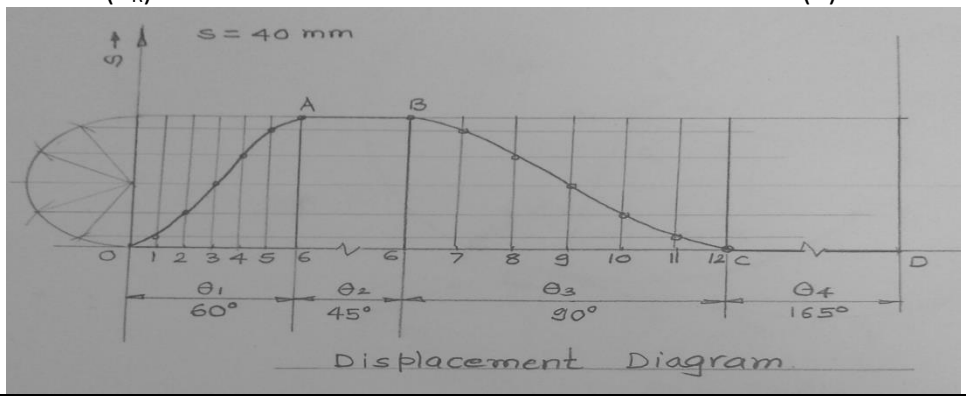
02</td></tr>
<tr><td>2</td><td>(d)</td><td>Differentiate between belt drive and gear drive.</td><td>04</td></tr>
<tr><td></td><td>Ans.</td><td>Difference between Belt and Gear Drive: (Any 04 Points, 01 Mark for each)
<table>
<tr><th>Basis</th><th>Belt Drive</th><th>Gear Drive</th></tr>
<tr><td>Power transmitting capacity</td><td>Less</td><td>High</td></tr>
<tr><td>Slip & Creep</td><td>Occurs</td><td>No</td></tr>
<tr><td>Material used</td><td>Flexible in nature</td><td>Rigid material used</td></tr>
<tr><td>Type of drive</td><td>Slip drive</td><td>Positive drive</td></tr>
<tr><td>Centre distance between the shafts</td><td>Medium or large</td><td>Very less</td></tr>
<tr><td>Overload taking capacity</td><td>Slips when overloaded</td><td>Damages when overloaded</td></tr>
<tr><td>Velocity Ratio</td><td>Does not remain constant</td><td>Remain constant</td></tr>
<tr><td>Use</td><td>Low to moderate power transmission</td><td>High power transmission</td></tr>
</table></td><td>04</td></tr>
</table>

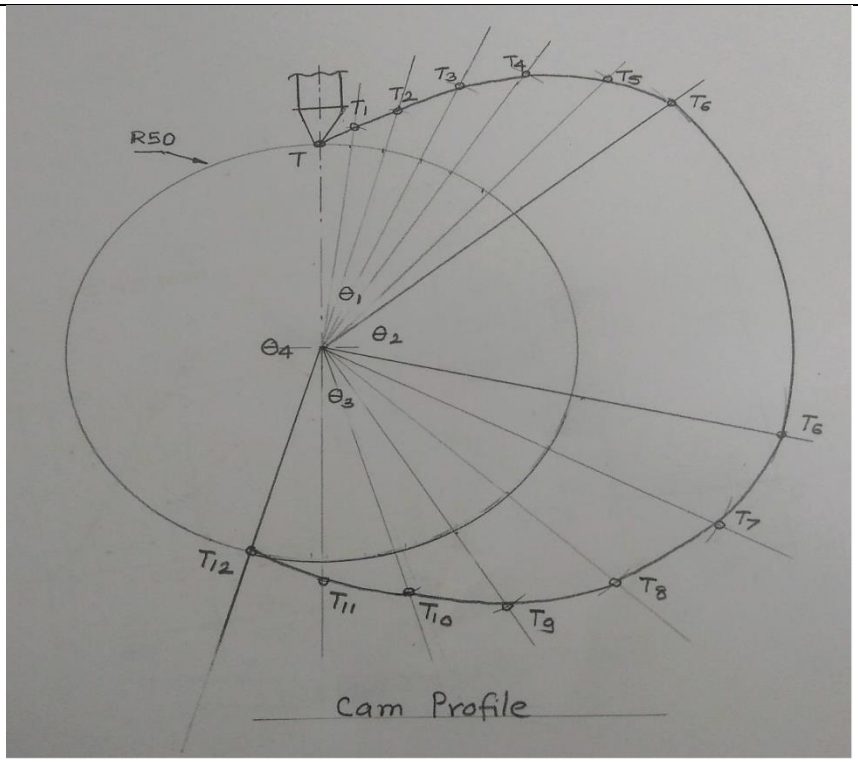
Q. No.	Sub Q. N.	Answer	Marking Scheme
3	(a)	**Draw a neat sketch of 'Locomotive coupler' mechanism. Explain its working in brief.**	**04**
		 **Figure: Coupler Rod of Locomotive** **(Link AD** = **Link BC** = Crank **Link CD** = Coupling Rod **Link AB** = Fixed Link = Frame) **Working of Coupler Rod of Locomotive:** It is an example of Double Crank Mechanism in which, Links AD and BC (having equal length) act as cranks and are connected to the respective wheels. Link CD acts as a coupling rod and link AB is fixed in order to maintain a Constant center to center distance between them. This mechanism is meant for ***transmitting rotary motion from one wheel to the other wheel.***	**02** **02**
3	(b)	**Name the suitable mechanism to be used for following applications:**	**04**
		(Correct Name of Suitable Mechanism for Given Application, 01 Mark for each) **S.N.** / **Application** / **Suitable Mechanism** **(i)** / **Lifting water from well** / Pendulum pump (Bull Engine) **(ii)** / **Connecting misaligned shaft** / Oldham's coupling **(iii)** / **Converting rotary motion into reciprocating motion** / Beam Engine (Crank & Lever Msm) **(iv)** / **Maintain constant relative motion between two rotary elements** / Coupling rod of locomotive	**04**

Q. No.	Sub Q. N.	Answer	Marking Scheme
3	(c)	**Explain the construction of 'Disc Brake' with neat sketch.**	**04**
	Ans.	**Construction of Disc Brake:** Modern vehicles always equipped with disc brakes on at least the front two wheels. It consists of mainly 3 parts, [1] Rotor [2] Caliper [3] Brake pads In between each piston and disc, friction pad held in position by springs. Higher applied forces can be used in disc brakes than in drum brakes, because the design of the rotor is stronger than the design of the drum. Due to this, large resistance is carried by flat disc. In this, Flat plate disc with flat friction pad are used against heavy drum. Friction surface directly exposed to air cooling which results better (faster) heat dissipation.  **Figure: Disc Brake**	**02** **02**
3	(d)	**Draw basic 'cam-follower' diagram showing its terminology (Minimum four terms)**	**04**
	Ans.	**Basic Cam Follower Profile:**  	**02 Marks for Cam Profile** **02 Marks for 04 Terms indicating on it**

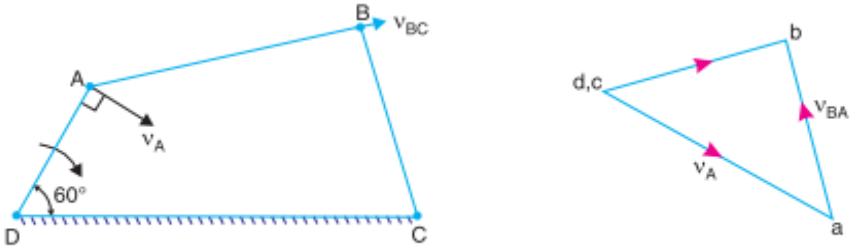
Q. No.	Sub Q. N.	Answer	Marking Scheme
3	(e)	**State the necessity of Balancing. List different types of Balancing Methods.**	**04**
		(02 Marks for Necessity, 02 Marks for Types) **Necessity of Balancing:** [1] The high speed of engines and other machines is a common phenomenon now-a-days. It is, therefore, very essential that all the rotating and reciprocating parts should be completely balanced as far as possible. [2] 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. [3] The balancing of unbalanced forces is caused by rotating masses, in order to minimize pressure on the main bearings when an engine is running. **Types of Balancing Methods:** **[1] Balancing of rotating masses:** (a) Balancing of a single rotating mass by a single rotating mass in the same plane (b) Balancing of a single rotating mass by two masses rotating in the different planes (c) Balancing of different masses rotating in the same plane (d) Balancing of different masses rotating in the different planes **[2] Balancing of Several masses revolving in same plane:**	**02** **02**

Q. No.	Sub Q. N.	Answer	Marking Scheme
4		**Attempt any TWO of the following (2 x 6)**	**12**
4	(a)	**Draw the labeled diagram of Crank and slotted lever Quick Return Mechanism.**	**06**
		Neat labeled Sketch of Crank and Slotted Lever Quick Return Mechanism:  	**04 Marks for suitable sketch** **02 Marks for Labeling**
4	(b)	**A crank of slider crank mechanism rotates clock wise at constant speed of 300 rpm. The crank is 150 mm and connecting rod is 600 mm long. Determine:** **(i) Linear velocity of the mid-point of connecting rod.** **(ii) Angular acceleration of connecting rod at a crank angle of 45º from inner dead centre position.**	**06**
	Ans.	**Given Data:** Given : N_{BO} = 300 r.p.m. or $\omega_{BO} = 2\pi \times 300/60 = 31.42$ rad/s; OB = 150 mm = 0.15 m ; BA = 600 mm = 0.6 m We know that linear velocity of B with respect to O or velocity of B, $v_{BO} = v_B = \omega_{BO} \times OB = 31.42 \times 0.15 = 4.713$ m/s ...(Perpendicular to BO)  (*a*) Space diagram. (*b*) Velocity diagram. (*c*) Acceleration diagram.	**01 Mark for Given Data** **01 Mark for each of Space, Velocity & Acc. Diagram**

Q. No.	Sub Q. N.	Answer	Marking Scheme
4	(b)	**(i) Linear velocity of the midpoint of connecting rod :** By measurement, we find that v_D = vector od = 4.1 m/s Ans. (ii) **Angular acceleration of connecting rod at a crank angle of 45º from inner dead centre position:** *Angular acceleration of the connecting rod* From the acceleration diagram, we find that $a^t_{AB} = 103$ m/s^2 ...(By measurement) We know that angular acceleration of the connecting rod AB, $\alpha_{AB} = \frac{a^t_{AB}}{BA} = \frac{103}{0.6} = 171.67$ rad/s^2 (Clockwise about B) Ans.	01 01
4	(c)	**Draw the profile of cam operating a knife edge follower from following data:** **(i) Follower to move outwards through 40 mm during 60º of cam rotation.** **(ii) Follower dwells for next 45º.** **(iii) Follower to return to its original position during next 90º.** **(iv) Follower to dwell for rest of the rotation. The displacement of follower is to take place with simple harmonic motion during both outward and return strokes. The least radius of cam is 50 mm. if the cam rotates at 300 rpm.**	06
		(02 Marks for Displacement Diagram, 04 Marks for Cam Profile) **Given Data:** Lift (S) = 40 mm Outward Stroke (θo) = 60º Dwell ($\theta_{D)}$) = 45º Return Stroke (θ_R) = 90º. Base Radius of Cam (R) = 50 mm  	02

Q. No.	Sub Q. N.	Answer	Marking Scheme
4	(c)		04
5		**Attempt any TWO of the following: (2 x 6)**	12
5	(a)	**Two parallel shafts whose centre lines are 4.8 m apart are connected by open belt drive. The diameter of larger pulley is 1.5 m and that of smaller pulley 1 m. the initial tension in the belt when stationary is 3 KN. The mass of the belt is 1.5 Kg/m length. The coefficient of friction between belt and pulley is 0.3. Taking centrifugal tension in to account, calculate power transmitted when smaller pulley rotates at 400 rpm.**	06
	Ans.	**Given Data:** **Open Belt Drive:** Where, C = 4.8 m D_1 = 1.5 m D_2 = 1 m N_2 = 400 rpm Ti = 3 KN = 3 x 10^3 N m = 1.5 Kg/m length μ = 0.3 Considering Centrifugal Tension (Tc) =mV^2 [1] We know that, Velocity (V) of the Open Belt Drive; $$v = \frac{\pi d_2 . N_2}{60} = \frac{\pi \times 1 \times 400}{60} = 21 \text{m/s}$$	**01 Mark for Given Data**

Q. No.	Sub Q. N.	Answer	Marking Scheme
5	(a)	**[2] Centrifugal Tension in Belt (Tc),** $(T_c) = mV^2 = 1.5 \times (21)^2 = 661.5$ N **[3] We know that initial tension in Belt (T_i) as,** Let, T_1 = Tension in Tight Side (N) T_2 = Tension in Slack Side (N) $T_i = \frac{T_1 + T_2 + 2T_C}{2}$ $3000 \times 2 = T_1 + T_2 + 2 \times (661.5)$ **$T_1 + T_2 = 4677$ N ……Eq. [1]** **[4] For an Open Belt Drive,** $\sin\alpha = \frac{r_1 - r_2}{x} = \frac{d_1 - d_2}{2x} = \frac{1.5 - 1}{2 \times 4.8} = 0.0521$ or $\alpha = 3°$ **So, angle of lap on the smaller pulley is;** $\theta = 180° - 2\alpha = 180° - 2 \times 3° = 174°$ $= 174° \times \pi / 180 = 3.04$ rad **[5] We know that relation between T_1 & T_2 is;** $2.3 \log\left(\frac{T_1}{T_2}\right) = \mu.\theta = 0.3 \times 3.04 = 0.912$ $\log\left(\frac{T_1}{T_2}\right) = \frac{0.912}{2.3} = 0.3965$ or $\frac{T_1}{T_2} = 2.5$ ……**E1. [2]** **From Eq.1 and Eq. 2 , we get,** $T_1 = 3341$ N ; and $T_2 = 1336$ N **[6] Power transmitted by Belt (P),** $P = (T_1 - T_2)\, v = (3341 - 1336)\, 21 = 42\,100$ W $= 42.1$ kW. **Answer: Power Transmitted by Belt = 42.1 KW**	**01 Mark for T_C & T_i Calculation** **01 Mark for ά & θ Calculation** **02 Marks for T_1 & T_2 Calculation** **01 Mark for Calculation of Power (P)**

Q. No.	Sub Q. N.	Answer	Marking Scheme
5	(b)	**A 4-bar mechanism has following dimensions: *l*(DA) = 300 mm, *l*(CB) = *l*(AB) = 360mm, *l*(DC) = 600 mm. the link 'DC' is fixed. The angle ADC is 60º. The driving link 'DA' rotates at a speed of 100 rpm clockwise and constant driving torque is 50 N-m. Calculate the velocity of point 'B' and angular velocity of driven link 'CB'.**	**06**
	Ans.	**Given Data:** N_{AD} = 100 rpm DA = 300 mm = 0.3 m T_A = 50 N-m ω_{AD} = 2 π x 100 /60 = 10.47 rad/sec. **Velocity of A w.r.t. D (V_{AD});** $v_{AD} = v_A = \omega_{AD} \times DA = 10.47 \times 0.3 = 3.14$ m/s ……Perpendicular to DA **Velocity of Point B:** **[1]** Since the link *DC* is fixed, therefore points d and c are taken as one point in the velocity diagram. Draw vector da perpendicular to *DA*, to some suitable scale, to represent the velocity of *A* with respect to *D* or simply velocity of A (i.e. V_{AD} or V_A) such that, Vector *da* =V_{AD} = V_A = 3.14 m/s **[2]** Now from point a, draw vector ab perpendicular to *AB* represents the velocity of *B* with respect to A (i.e. V_{BA}), and from point c draw vector *cb* perpendicular to *CB* to represent the velocity of *B* with respect to *C* or simply velocity of B (i.e. V_{BC} or V_B). The Vectors ab and cb intersect at b. **[3]** By measurement, we find that velocity of point B, V_B = V_{BC} = vector *cb* = 2.25 m/s  (*a*) Space diagram. (*b*) Velocity diagram.	**01 Mark for Given Data** **01 Mark for Calculation of V_{AD} and V_B** **02 Marks for Space & Vector Diagram**

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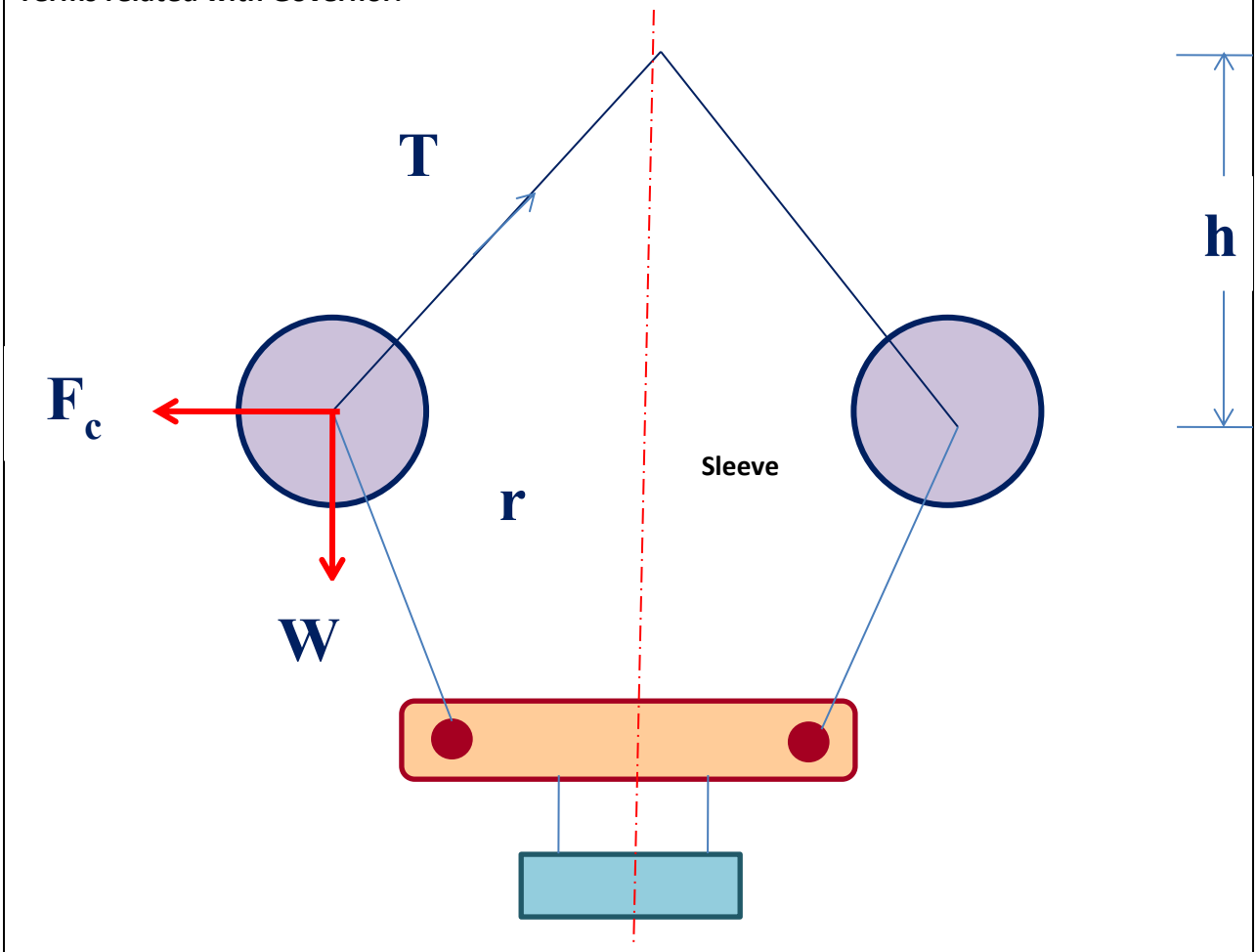
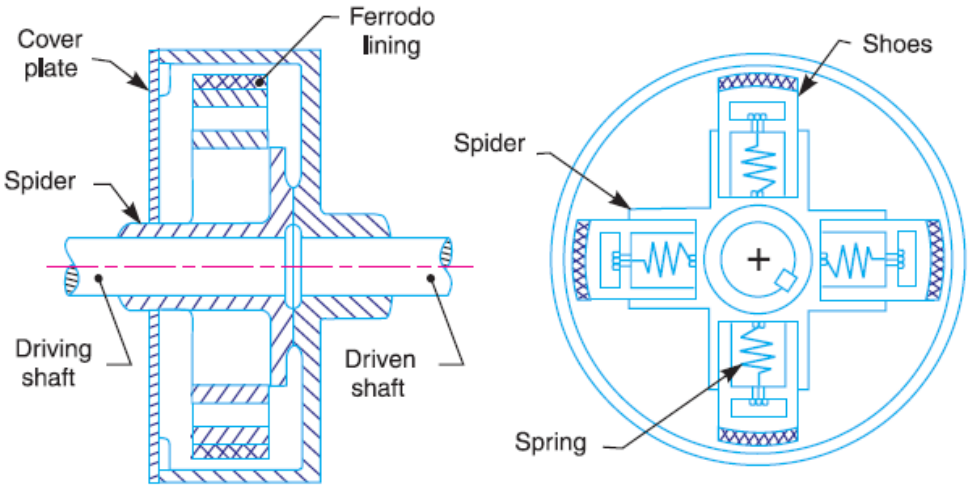
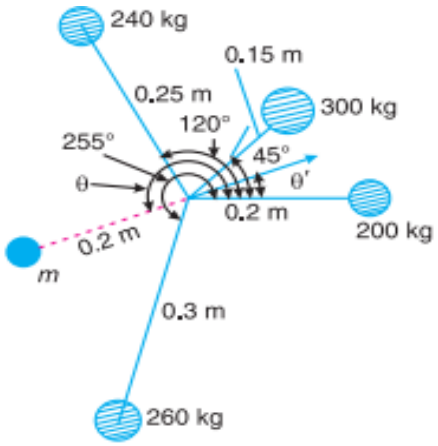
Q. No.	Sub Q. N.	Answer	Marking Scheme
5	(b)	**[4] Angular Velocity of driven link CB** Since *CB* = 360 mm =0.36 m, therefore angular velocity of the driven link *CB*, $\omega_{BC} = \frac{v_{BC}}{BC} = \frac{2.25}{0.36} = 6.25$ rad/s (Clockwise about *C*)	**02 Marks for ω_{BC}**
5	(c)	**Explain the following terms of centrifugal governor with neat sketch:** **(i) Height of Governor** **(ii) Equilibrium Speed** **(iii) Sleeve Lift**	**06**
	Ans.	**(1.5 Marks for Sketch, 1.5 Marks for significance of each term)** **Terms related with Governor:**  **(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 as shown in figure. (ii) **Equilibrium Speed:** It is the speed at which the governor balls, arms etc. are in complete equilibrium & the sleeve does not tend to move upwards or downwards.	**1.5 Mark** **1.5 Mark** **1.5 Mark** **1.5 Mark**

		(iii) **Sleeve Lift:** It is the vertical distance which the sleeve travels due to change in equilibrium speed.	
6		**Attempt any TWO of the following: (2 x 6)**	**12**
6	**(a)**	**Two pulleys one 450 mm diameter and the other 200 mm diameter are on parallel shafts 1.95 m apart and are connected by a crossed belt. Find the length of belt required and angle of contact between belt and each pulley. Estimate the power transmitted by belt when the larger pulley rotates at 200 rpm. If the maximum tension in the belt is 1 KN and coefficient of friction between belt and pulley is 0.25.**	**06**
6	**(a)**	**Given Data:** **Crossed Belt Drive** D_1 = 450 mm = 0.45 m D_2 =200 mm = 0.20 m C = 1.95 m N_1 = 200 rpm μ = 0.25 $T_1 = T_{max}$ = 1 KN = 1000 N L_{Cross} = ? Θs = ? P = ?	**01 Mark for Given Data**
		[1] We know that speed of the Belt is; $$v = \frac{\pi d_1 . N_1}{60} = \frac{\pi \times 0.45 \times 200}{60} = 4.714 \text{ m/s}$$	**01 Mark for Speed**
		[2] Length of the Crossed Belt Drive (L_{Cross}); $$L = \pi(r_1 + r_2) + 2x + \frac{(r_1 + r_2)^2}{x}$$ $$= \pi(0.225 + 0.1) + 2 \times 1.95 + \frac{(0.225 + 0.1)^2}{1.95} = 4.975 \text{m}$$	**01 Mark for L_{Cross}**
		[3] Angle of Contact between belt and each pulley; $$\sin\alpha = \frac{r_1 + r_2}{x} = \frac{0.225 + 0.1}{1.95} = 0.1667 \quad \text{or} \quad \alpha = 9.6°$$ $$\theta = 180° + 2\alpha = 180° + 2 \times 9.6° = 199.2°$$ $$= 199.2 \times \frac{\pi}{180} = 3.477 \text{ rad}$$ **Ans.**	**01 Mark for Θ**
		[4] Power transmitted by Belt; Let, T2 = Tension in Slack side of the belt We know that, $$2.3 \log\left(\frac{T_1}{T_2}\right) = \mu . \theta = 0.25 \times 3.477 = 0.8692$$ $$\log\left(\frac{T_1}{T_2}\right) = \frac{0.8692}{2.3} = 0.378 \quad \text{or} \quad \frac{T_1}{T_2} = 2.387 \quad \text{...(Taking antilog of 0.378)}$$	**01**

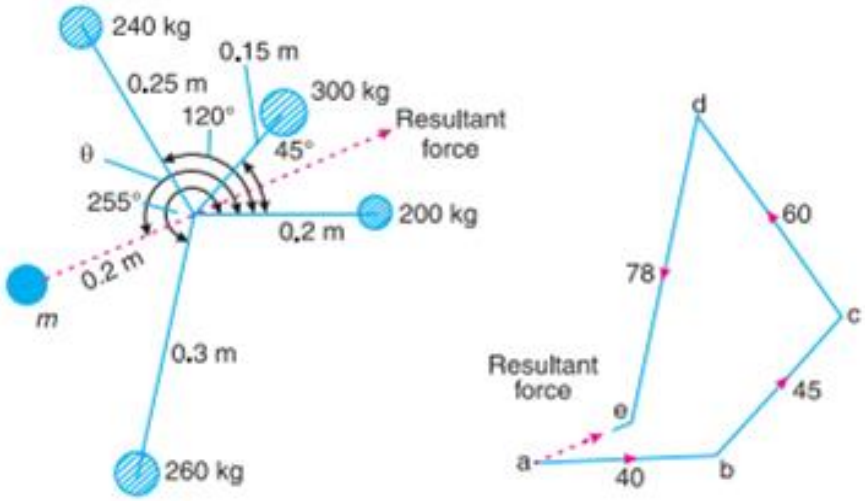
		$T_2 = \frac{T_1}{2.387} = \frac{1000}{2.387} = 419$ N	**Mark for T_2**
6	**(a)**	**Power transmitted by belt (P) is;** **$P = (T_1 - T_2) \times V$** $= (1000 - 419)\,4.714 = 2740\ \text{W} = 2.74\ \text{kW}$ Answers: **L_{Cross} = 4.975 m** Θs = **3.477 rad.** P **= 2.74 KW**	**01 Mark for P**
6	**(b)**	**Draw the constructional details diagram of Centrifugal clutch. Explain its working principle.**	**06**
	Ans.	**(03 Marks for neat labeled sketch, 03 Marks for Working principle in brief)**  Centrifugal clutch. **Working Principle of Centrifugal Clutch:** The centrifugal clutch uses ***centrifugal force***, instead of spring force for keeping it in engaged position. Also, it does not require clutch pedal for operating the clutch. The clutch is operated automatically depending upon the engine speed. The vehicle can be stopped in gear without stalling the engine. Similarly the vehicle can be started in any gear by pressing the accelerator pedal. This makes the driving operation very easy. **OR**	**03 Marks for neat labeled sketch** **03 Marks for Appropriate principle of working**

Q. No.	Sub Q. N.	Answer	Marking Scheme
6	(b)	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 is 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 shoe is revolving. A little consideration will show that 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. The increase of speed causes the shoe to press harder and enables more torque to be transmitted.	
6	(c)	**The weights of four masse A, B, C, D are 200 Kg, 300 Kg, 240 Kg and 260 Kg respectively. The corresponding radii of rotation are 200 mm, 150 mm, 250 mm and 300 mm respectively and the angle between successive masses are 45º, 75º and 135º. Find the position and magnitude of the balance weight required if its radius of rotation is 200 mm.**	**06**
	Ans.	**Given Data: (Either solve by Analytical Or Graphical Method)** Given : $m_1 = 200$ kg ; $m_2 = 300$ kg ; $m_3 = 240$ kg ; $m_4 = 260$ kg ; $r_1 = 0.2$ m ; $r_2 = 0.15$ m ; $r_3 = 0.25$ m ; $r_4 = 0.3$ m ; $\theta_1 = 0°$; $\theta_2 = 45°$; $\theta_3 = 45° + 75° = 120°$; $\theta_4 = 45° + 75° + 135° = 255°$; $r = 0.2$ m  **Figure: Space Diagram**	**01 Mark for Given Data** **02 Mark for Space Diagram**

Q. No.	Sub Q. N.	Answer	Marking Scheme
6	(c)	Let m = Balancing mass, and θ = The angle which the balancing mass makes with m_1. Since the magnitude of centrifugal forces are proportional to the product of each mass and its radius, therefore $m_1 \cdot r_1 = 200 \times 0.2 = 40$ kg-m $m_2 \cdot r_2 = 300 \times 0.15 = 45$ kg-m $m_3 \cdot r_3 = 240 \times 0.25 = 60$ kg-m $m_4 \cdot r_4 = 260 \times 0.3 = 78$ kg-m **[a] Analytical Method:** Resolving $m_1.r_1$, $m_2.r_2$, $m_3.r_3$ and $m_4.r_4$ horizontally, $\Sigma H = m_1 \cdot r_1 \cos\theta_1 + m_2 \cdot r_2 \cos\theta_2 + m_3 \cdot r_3 \cos\theta_3 + m_4 \cdot r_4 \cos\theta_4$ $= 40\cos 0° + 45\cos 45° + 60\cos 120° + 78\cos 255°$ $= 40 + 31.8 - 30 - 20.2 = 21.6$ kg-m Now resolving vertically, $\Sigma V = m_1 \cdot r_1 \sin\theta_1 + m_2 \cdot r_2 \sin\theta_2 + m_3 \cdot r_3 \sin\theta_3 + m_4 \cdot r_4 \sin\theta_4$ $= 40\sin 0° + 45\sin 45° + 60\sin 120° + 78\sin 255°$ $= 0 + 31.8 + 52 - 75.3 = 8.5$ kg-m $\therefore$ Resultant, $R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \sqrt{(21.6)^2 + (8.5)^2} = 23.2$ kg-m We know that $m \cdot r = R = 23.2$ or $m = 23.2 / r = 23.2 / 0.2 = 116$ kg **Ans.** and $\tan\theta' = \Sigma V / \Sigma H = 8.5 / 21.6 = 0.3935$ or $\theta' = 21.48°$ Since θ' is the angle of the resultant R from the horizontal mass of 200 kg, therefore the angle of the balancing mass from the horizontal mass of 200 kg, $\theta = 180° + 21.48° = 201.48°$ **Ans.** **OR**	**03 Marks for Calculation of Magnitude and Direction by Analytically.**

Q. No.	Sub Q. N.	Answer	Marking Scheme
6	(c)	**[b] Graphical Method:**	

Now draw the vector diagram with the above values, to some suitable scale, as shown in Fig (*b*). The closing side of the polygon *ae* represents the resultant force. By measurement, we find that *ae* = 23 kg-m.



(*a*) Space diagram. (*b*) Vector diagram

The balancing force is equal to the resultant force, but ***opposite*** in direction as shown in Fig. 21.6 (*a*). Since the balancing force is proportional to *m.r*, therefore

$m \times 0.2$ = vector ea = 23 kg-m or $m = 23/0.2 =$ **115 kg Ans.**

By measurement we also find that the angle of inclination of the balancing mass (*m*) from the horizontal mass of 200 kg,

$\theta = 201°$ **Ans.**

02 Marks for Space Diagram

02 Marks for Vector Diagram

01 Marks for Calculation of Magnitude & Direction by Graphically.