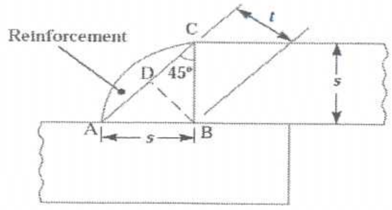
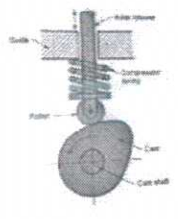
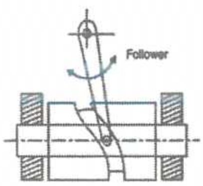
SET 2

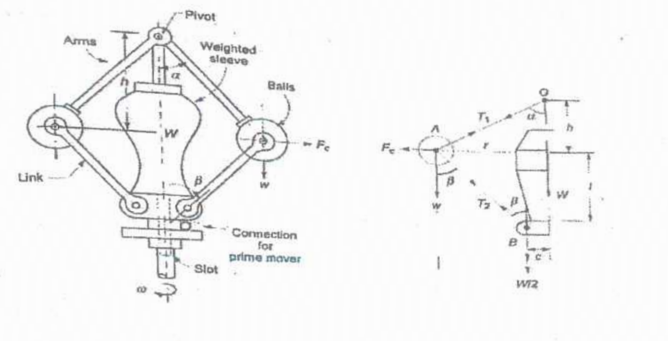
Scoring Indicators

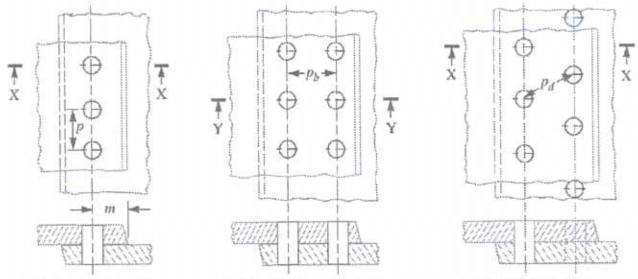
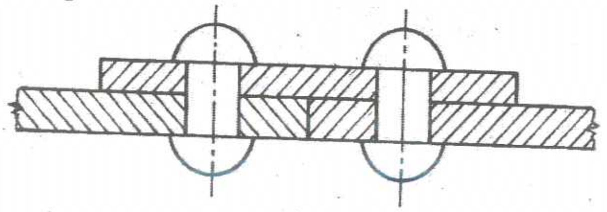
COURSE NAME: DESIGN OF MACHINE ELEMENTS

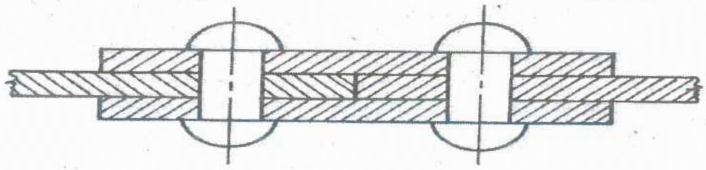
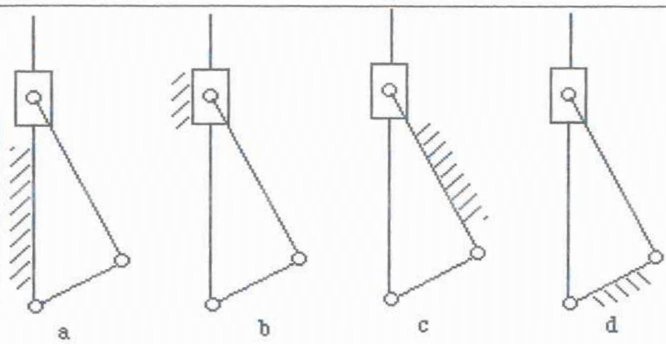
COURSE CODE: 5021 **QID: 2109230027**

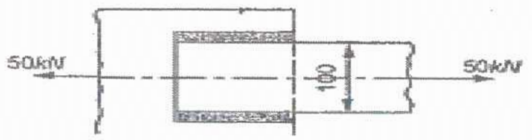
Q. No.	Scoring Indicators	Split Score	Sub Total	Total Score
	PART A			**9**
I. 1	Kinematic chain	1	1	1
I. 2	Ratio of yield stress to design stress	1	1	1
I. 3	29^0	1	1	1
I. 4	Amount of torque required to twist the shaft through one radians.	1	1	1
I. 5	Thickness = d/4 = 60/4 = 15mm	1	1	1
I. 6	Height of the governor	1	1	1
I. 7	Ratio of difference between maximum and minimum speed to mean speed.	1	1	1
I. 8	Full journal bearing	1	1	1
I. 9	Uneven contraction and expansion in belt as it transforms from tight side to slack side	1	1	1
	PART B			**24**
II. 01	The length of each side is known as leg or size of the weld and the perpendicular distance of the hypotenuse from the intersection of legs (i.e. BD) is known as throat thickness. 	Figure 1 mark Explanation 2 mark	1+2= 3	3
II. 02	Shafts are given specific names according to their use to which it is put as follows **1.Prime mover shafts** Prime mover shaft is connected to source of power. For example, engine shafts,	One mark each	1x3	3

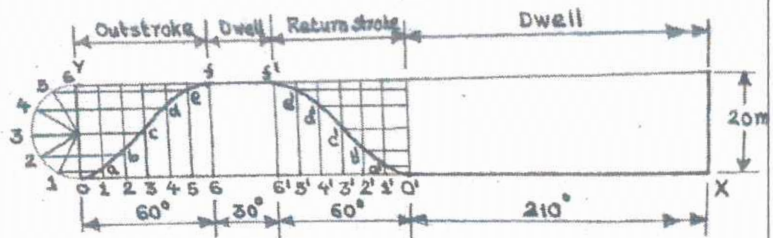
	generator shafts, motor shafts, turbine shaft etc. **2.Machine shafts** Machine shafts form an integral part of the machine itself. For example, crank shaft. **3.Power transmission shafts** These shafts are used to transmit power between the source and the machines using power. For example, line shafts, counter shafts, jack shafts etc.			
II. 03	Sunk keys, feather keys, woodruff key, tangent key, round key, saddle key, splines	Any 3 with sketches	1x3	3
II. 04	*The hollow transmission shafts offer the following advantages over solid transmission shafts.* *(i) Hollow shafts are lighter than solid shafts. These shafts are more stronger per kilogram of material.* *(ii) They allow internal support or permit other shafts to operate through the interior.*	1.5x2 = 3	1.5+1.5	3
II. 05	Width = d/4 = 45/4 = 11.25 mm = 14 mm Thickness = width (square key) $T=\frac{\pi \tau d^3}{16} = \pi*80*45^3/16 = 1431388.15$ N.mm $T = l*w*\tau*d/2$ $l = 2T/(w*\tau*d) = 56.8$ mm	Equation – 1 mark Torque – 1 mark Dimensions- 1 mark	1+1+1	3
II. 06	Disc cam, wedge cam, cylindrical cam  Radial or Disc cam  CYLINDRICAL CAM	Any two cams- 1 mark Figure – 2 mark	1+2	3
II. 07	Rigid Couplings and flexible couplings Rigid – muff couplings, flange couplings, Flexible couplings – Oldham coupling, universal coupling	Types -2 mark Explanation-1 mark	2+1	3

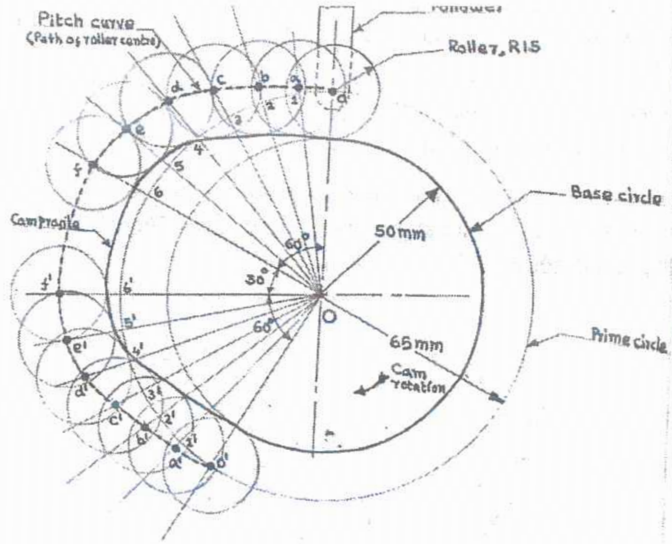
II. 08	 *Fig 8.3 Porter governor* Simple watt governor is unsuitable for high speeds. However this drawback has been overcome by loading the governor with a dead weight or by means of a spring. If the sleeve of a watt governor is loaded with a heavy weight, it becomes a porter governor. *Fig.*8.3 shows a porter governor which is dead weight type of centrifugal governor. It consists of two masses called the governor balls attached to the spindle with the help of four links or arms. The lower arms are attached to the sleeve which acts as a central weight. Governor balls are rotate at different speeds depends upon the load on the engine about the axis of the governor shaft, which is driven through suitable gearing from the engine crankshaft. The speed of the rotation of balls increases as the load on the engine decreases. Due to the increase of speed, the governor balls fly outwards and the sleeve moves upwards thus closing the working fluid passage till the engine speed comes back to its designed speed. On the other hand the speed of rotation of balls decreases as the load on the engine increases and the governor balls move near to the governor axis due to reduction in the centrifugal force on the fly balls. At that time the sleeve moves downwards thus opening the working fluid passage more till the engine speed comes back to its designed speed. The speed of rotation of balls due to the centrifugal force is just balanced by the inward controlling force provided by dead weight *Fig* 8.3 (b) shows the forces acting on the governor.	Figure -2 Explanation-1	2 +1=3	3
II. 09	The main *function* of a flywheel is to act as reservoir of energy in a machine. It absorb the excess energy, when the energy during the period is more than the requirement and release it when the energy required for doing useful work is less during the period. Without the energy supplied by the flywheel, large and intolerable fluctuations in speed would occur. Thus flywheel avoiding cyclic fluctuations in angular velocity thus keep the angular velocity of a prime mover more nearly constant. A flywheel may not be used, if there is the load output requirements are constant and the power input is constant. If the power input is variable, with the load output requirements constant, a flywheel can be used to smooth out the operation; if the power input is constant and the load output requirements are variable, again flywheel can be used to smooth out the operation. The internal combustion engine using the crank and connecting rod mechanism is an example of the varying supply of energy. Only during the power or expansion stroke is energy supplied; during suction, compression and exhaust strokes energy is extracted. The punch press is an example of varying load or resistance, the maximum resistance occurs at the instant of punching, with only frictional resistance during the remainder of the cycle.	Any 3 functions one mark each	1x3= 3	3
II. 10	**Advantages** High flexibility and Wear resistance. Better crushing resistance. Higher strength as compared to round strand. Less resistance of the bending fatigue. Reduction of mechanical stress on the rope as well as the sheave. Less damages Significant Cost Reduction	Advantages -any 3 points 3x1=3	1x3= 3	3
PART C				**42**
III	Following are the three types of constrained motions: 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. For example, the piston and cylinder (in a steam engine) form a pair and the motion of the piston is limited to a definite direction (i.e. it will only	3 types 3+3+2	7	7

	reciprocate) relative to the cylinder irrespective of the direction of motion of the crank. The motion of a square bar in a square hole, and the motion of a shaft with collars at each end in a circular hole, are also examples of completely constrained motion. 2. **Incompletely constrained motion**. When the motion between a pair can take place in more than one direction, then the motion is called an incompletely constrained motion. The change in the direction of impressed force may alter the direction of relative motion between the pair. A circular bar or shaft in a circular hole, is an example of an incompletely constrained motion as it may either rotate or slide in a hole. These both motions have no relationship with the other. **3. Successfully constrained motion.** When the motion between the elements, forming a pair, is such that the constrained motion is not completed by itself, but by some other means, then the motion is said to be successfully constrained motion. Consider a shaft in a foot-step bearing. The shaft may rotate in a bearing or it may move upwards. This is a case of incompletely constrained motion. But if the load is placed on the shaft to prevent axial upward movement of the shaft, then the motion of the pair is said to be successfully constrained motion. The motion of an I.C. engine valve (these are kept on their spring) and the piston reciprocating inside an engine cylinder seat by a are also the examples of successfully constrained motion.			
IV	Lap Joint A lap joint is that in which one plate overlaps the other and the two plates are then riveted together.  (*a*) Single riveted lap joint. (*b*) Double riveted lap joint (Chain riveting). (*c*) Double riveted lap joint (Zig-zag riveting). Butt Joint A butt joint is that in which the main plates are kept in alignment butting (i.e. touching) each other and a cover plate (i.e. strap) is placed either on one side or on both sides of the main plates. The cover plate is then riveted together with the main plates.  (A) SINGLE COVER PLATE BUTT-JOINT	Lap Joint – 4 marks (figure-2 mark, types-2 mark) Butt joint – 3 marks (types-1 mark, figure-2 mark)	4+3=7	7

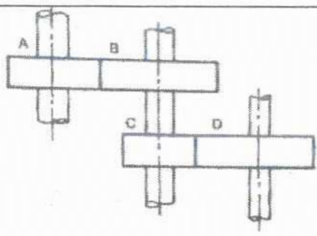
	 DOUBLE COVER SINGLE RIVETED BUTT JOINT			
V	 **First inversion** This inversion is obtained when link 1 (ground body) is fixed. Application- Reciprocating engine, Reciprocating compressor etc... **Second inversion** This inversion is obtained when link 2 (crank) is fixed. Application- Whitworth quick return mechanism, Rotary engine, etc... **Third inversion** This inversion is obtained when link 3 (connecting rod) is fixed. Applications - Slotted crank mechanism, Oscillatory engine etc.., **Fourth inversion** This inversion is obtained when link 4 (slider) is fixed. Application- Hand pump, pendulum pump or Bull engine, etc.	Figures-3marks Explanation – 4 marks	3+4	7
VI	We know that the maximum load which the plates can carry for double parallel fillet welds (P), $50 \times 10^3 = 1.414\ s \times l \times \tau$ $= 1.414 \times 12.5 \times l \times 56 = 990\ l$ $\therefore l = 50 \times 10^3 / 990 = 50.5$ mm	Figure=2 mark Equations = 2 marks Calculation – 3 marks	2+2+3=7	7

	 			
VII	T= 2860×10^3 N.mm L = 1498 mm $\Theta = 1^0$ G = 79 GPa = 79 $\times 10^3$ MPa $\Theta = 584TL/(Gd^4)$ $d = (584TL/(G\,\Theta))^{1/4}$ d = 75.01 mm, d= 80 mm	Equation- 2 marks Calculation = 4 marks Standard diameter = 1 mark	2+4+1=7	7
VIII	Diameter of solid circular shaft $= d$ Outside diameter of hollow shaft, $d_o = d$ Inside diameter of hollow shaft, $d_i = 0.5d_o = 0.5d$ **Analysis :** Diameter ratio, $k = \frac{d_i}{d_o} = \frac{0.5d_o}{d_o}$ or $\frac{0.5d}{d} = 0.5$ *Comparison by weight* *Weight of hollow shaft = Cross-sectional area × Length × Density* $W_H = A_H \times l_H \times \rho_H = \frac{\pi}{4}(d_o^2 - d_i^2) \times l_H \times \rho_H$ $= \frac{\pi}{4} d_o^2 \left(1 - \left(\frac{d_i}{d_o}\right)^2\right) \times l_H \times \rho_H = \frac{\pi}{4} d_o^2 (1-k^2) \times l_H \times \rho_H$ *Weight of solid shaft = Cross-sectional area × Length × Density* $W_S = A_S \times l_S \times \rho_S = \frac{\pi}{4} d^2 \times l_H \times \rho_H$ $\therefore \frac{W_H}{W_S} = \frac{\frac{\pi}{4} d_o^2 (1-k^2) \times l_H \times \rho_H}{\frac{\pi}{4} d^2 \times l_H \times \rho_H} = \frac{d_o^2 (1-k^2)}{d^2} = \frac{d^2 (1-k^2}{d^2}$ $= 1 - k^2 = 1 - (0.5)^2 = \mathbf{0.75}$ *Comparison by stiffness* Stiffness of hollow shaft, $q_H = \frac{T_H}{\theta_H} = \frac{G_H J_H}{l_H} = \frac{G_H}{l_H} \times \frac{\pi}{32} d_o^4 (1-k^4) = \frac{G_H}{l_H} \times \frac{\pi}{32} d^4 (1-k^4)$ Stiffness of solid shaft, $q_S = \frac{T_S}{\theta_S} = \frac{G_S J_S}{l_S} = \frac{G_S}{l_S} \times \frac{\pi}{32} d^4$ $\therefore \frac{q_H}{q_S} = \frac{\frac{G_H}{l_H} \times \frac{\pi}{32} d^4 (1-k^4)}{\frac{G_S}{l_S} \times \frac{\pi}{32} d^4} = 1 - k^4 = 1 - (0.5)^4 = \mathbf{0.9375}$	Equations – 4 marks Calculation- 3 mark	4+3=7	7

<table>
<tr>
<td>IX</td>
<td>




</td>
<td>Displacement diagram- 3 mark
Profile- 4 mark</td>
<td>3+4= 7</td>
<td>7</td>
</tr>
<tr>
<td>X</td>
<td>Compare the distinguishing features of fly wheel and the governor are presented in the table 8.1 given below :
<table>
<tr><th>Flywheel</th><th>Governor</th></tr>
<tr><td>1. Flywheel stores andredistributes energy within a cycle to control speed.
2. A flywheel takes care of fluctuations of speedduring a cycle.
3. A flywheel works continuously from cycle to cycle
4. A flywheel has no control over the quality and quantity of working agent.
5. A flywheel is not essential element of every prime mover.
6. It is used only in case when there is undesirable cyclic fluctuation of energy output or input.</td>
<td>1. Governor controls the amount of fuel to an engine to matchthe load requirements to maintain a specified speed.
2. A governor takes care of speed due to variation of load.
3. A governor works intermittently only when there is change in load.
4. A governor takes care of change of quality and quantity of the working agent.
5. A governor is an essential element of every prime mover.
6. It is an adjuster of supply of fuel with demand.</td></tr>
</table>
</td>
<td>0.5 marks each</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>XI</td>
<td>D1 = 300 mm
D2 = 200 mm
C = 5.3 m = 5300 mm
Open belt drive length = L= $\frac{\pi*(D1+D2)}{2} + 2C + \frac{(D2-D1)^2}{4C}$
L = 785.39+10600+0.471 = 11385.86 mm = 11.38 m</td>
<td>Equations – 3 marks
Calculation – 4 marks</td>
<td>4+3= 7</td>
<td>7</td>
</tr>
</table>

XII	$T_A = 30, T_B = 40, T_C = 60, T_D = 40$ $N_A = 36$ rpm $N_A/N_C = T_C/T_A$ $N_C = 36x30/60 = 18$ rpm $N_A/N_D = T_D/T_A$ $N_D = 36x30/40$ $= 27$ rpm	Equations – 3 marks Speed of gear C = 2 mark Speed of gear D = 2 mark	3+2+2=7	7
XIII	 *Fig 10.13 Arrangement of gear wheels* Using the relation for train value of compound gear train. $\frac{N_D}{N_A} = \frac{T_A T_C}{T_B T_D}$ Or, Speed of spur gear wheel $D, N_D = \frac{T_A T_C}{T_B T_D} \times N_A$ $= \frac{25 \times 35}{50 \times 70} \times 300 = 75$ rpm	Equations – 3 marks Calculation – 4 marks	3+4=7	7
XIV	Diameter of driving pulley, $d_1 = 300$ mm Speed of driving pulley, $N_1 = 200$ rpm Distance between pulleys, $C = 3$ m $= 3 \times 10^3$ mm Speed of driven pulley, $N_2 = 120$ rpm Thickness of the belt, $t = 5$ mm Slip at each stage, S_1 and $S_2 = 3\%$ *Analysis:* Total percentage of slip, $S = S_1 + S_2$ $= 3 + 3 = 6\%$ Using the relation for velocity ratio considering thickness and slip, i.e., $\frac{N_2}{N_1} = \frac{d_1 + t}{d_2 + t}\left(1 - \frac{S}{100}\right)$ ∴ Diameter of second pulley, $d_2 = \left((d_1 + t)\left(1 - \frac{S}{100}\right) \times \frac{N_1}{N_2}\right) - t = \left((300 + 5)\left(1 - \frac{6}{100}\right) \times \frac{200}{120}\right) - 5$ $= 472.83$ mm Using the relation for length of belt in open belt drive $L_o = \frac{\pi}{2}(d_2 + d_1) + 2C + \frac{(d_2 - d_1)^2}{4C}$ $= \frac{\pi}{2}(472.83 + 300) + 2 \times 3 \times 10^3 + \frac{(472.83 - 300)^2}{4 \times 3 \times 10^3}$ $= 7216.45$ mm $= 7.22$ m Re... the length of the belt in open d...	Equations- 3 marks Calculation- 4 mark	3+4=7	7