TED (21) – 5021
REVISION : 2021

QID - 2109230030

Reg. No. .....
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DIPLOMA EXAMINATION IN ENGINEERING/TECHNOLOGY/ MANAGEMENT/ COMMERCIAL PRACTICE.

Design of Machine Elements

(Maximum Marks: 75) [Time : 3 hours]

PART A

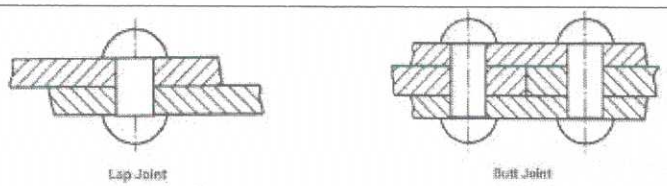
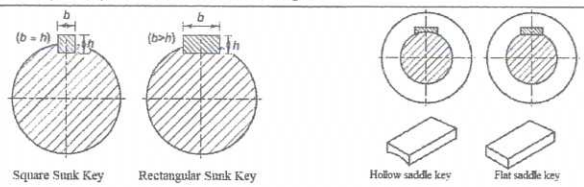
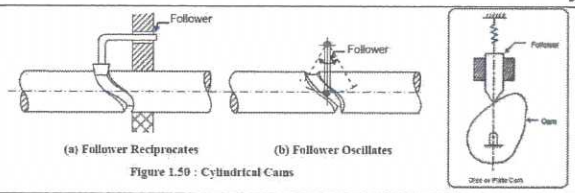
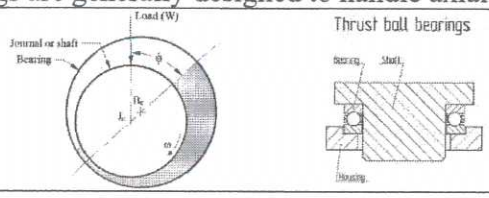
I. Answer **all** the following questions in one word or one sentence. Each question carries 1 mark **(9 x 1 = 9 marks)**

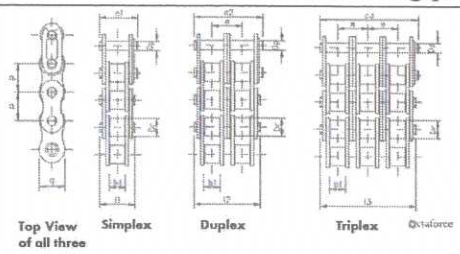
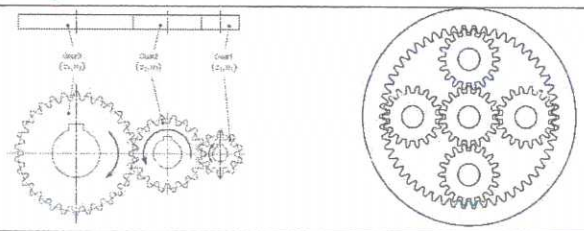
Q. No.	Scoring Indicators	Split Score	Sub Total
1	Major diameter	1	1
2	More than	1	1
3	Loose, tight	1	1
4	machine	1	1
5	increases	1	1
6	flexible	1	1
7	fluctuation of energy	1	1
8	short	1	1
9	greater than one	1	1

PART B

II. Answer **any eight** questions from the following. Each question carries 3 marks. **(8 x 3 = 24 marks)**

Q. No.	Scoring Indicators	Split Score	Sub Total
1	A pair of links having surface or area contact between the members is known as a lower pair.	1.5	3
	When a pair has a point or line contact between the links, it is known as a higher pair.	1.5	
2	Riveted Lap joints are made by placing two plates above or below each other, creating a hole in these two plates & fixing the rivet inside the holes of the two plates.	1	3
	The butt joint is placed on either side of the main plate and on both sides of the plate by covering the plate, and holes are made at the joint of the main plate, and a rivet is inserted into the cover plate and each hole of both plates.	1	

		1	
3	Medium carbon steel, high carbon steel, alloy steels include nickel, nickel chromium etc	3 x1	3
4	Transmission shaft(line shafts, jack shafts, counter shafts), Machine shaft	1	3
	Transmission shafts are used to transmit power between source and the machines using power. Line shafts is long continuous shaft. Jack shaft is directly connected to source of power and from which other shafts are driven. Counter shafts receives power from line shafts and transmits to machine. Machine shafts are incorporated within the machine, such as crank shaft.	2	
5	Sunk key is the key that fits into keyways both in the shaft and in the secured member of the machinery. A Saddle key is a key which fits in the keyway of the hub only.	1	3
		2	
6	In Disc or plate cam the follower moves in a plane perpendicular to the axis of rotation of the camshaft. A cylindrical cam or barrel cam is a cam in which the follower rides on the surface of a cylinder.	1	3
		2	
7	The flywheel controls and maintains the cyclic fluctuation of speed by gaining energy during the power stroke and releasing the energy during the remaining stroke.	2	3
	The flywheel is basically a reservoir of energy.	1	
	Journal bearings are generally designed to handle radial loads while thrust bearings are generally designed to handle axial loads.	1	3
		2	

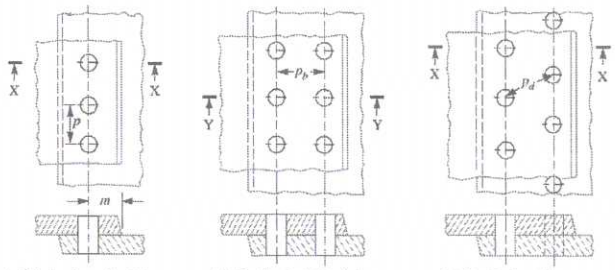
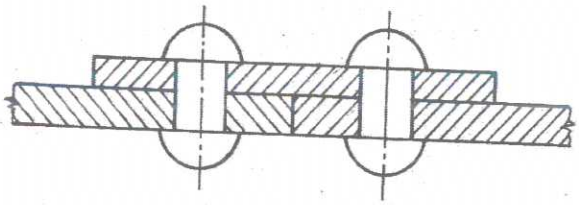
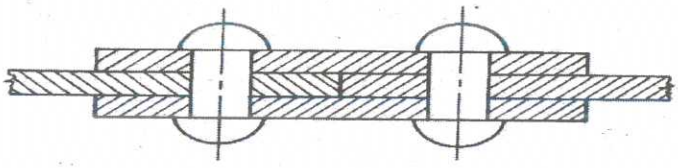
9	Simplex chain is a general-purpose transmission or drive chain available in single row. Duplex chain features two roller chains running parallel rather than a single one found with simplex chains. Triplex chain features three roller chains running parallel.	1	3
		2	
10	A gear train is a machine element of a mechanical system formed by mounting gears on a frame so the teeth of the gears engage. A simple gear train is one that has only one gear on each shaft. A compound gear train is a gear arrangement that employs several gears on a single shaft.	1	3
		2	

PART C

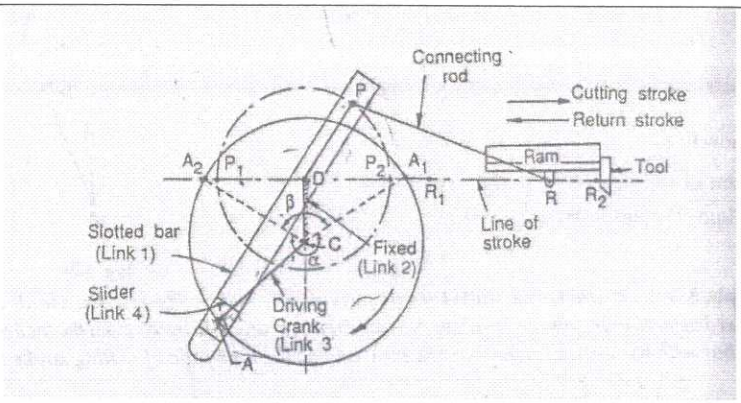
Answer **all** questions from the following. Each question carries 7 marks.
(6 x 7 = 42 marks)

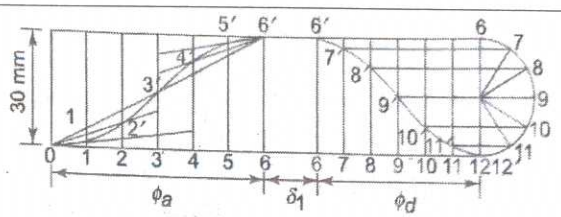
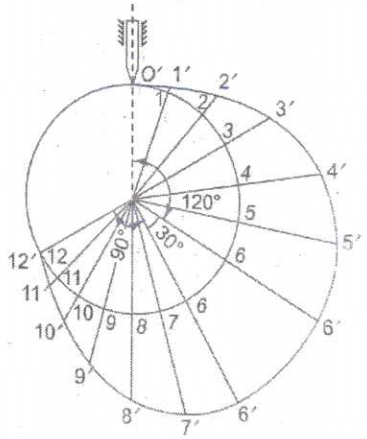
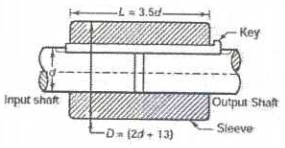
Q. No.	Scoring Indicators	Split Score	Sub Total
III.	1. According to the type of relative motion between the elements The kinematic pairs according to type of relative motion between the elements may be classified as discussed below: (a) Sliding pair. When the two elements of a pair are connected in such a way that one can only slide relative to the other, the pair is known as a sliding pair. The piston and cylinder, cross-head and guides of a reciprocating steam engine, ram and its guides in shaper, tail stock on the lathe bed etc. are the examples of a sliding pair. A little consideration will show that a sliding pair has a completely constrained motion. (b) Turning pair. When the two elements of a pair are connected in such a way that one can only turn or revolve about a fixed axis of another link, the pair is known as turning pair. A shaft with collars at both ends fitted into a circular hole, the crankshaft in a journal bearing in an engine, lathe	3 types 3+3+2	7

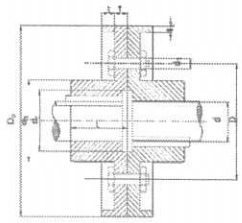
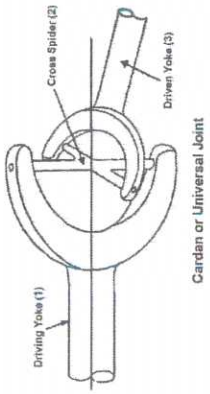
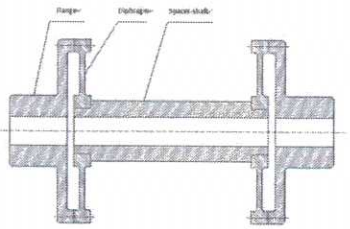
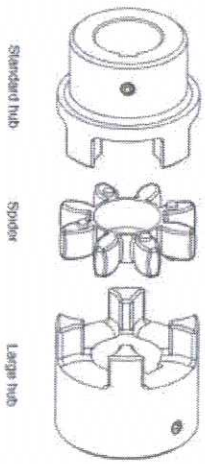
	spindle supported in head stock, cycle wheels turning over their axles etc. are the examples of a turning pair. A turning pair also has a completely constrained motion. (c) Rolling pair. When the two elements of a pair are connected in such a way that one rolls over another fixed link, the pair is known as rolling pair. Ball and roller bearings are examples of rolling pair. (d) Screw pair. When the two elements of a pair are connected in such a way that one element can turn about the other by screw threads, the pair is known as screw pair. The lead screw of a lathe with nut, and bolt with a nut are examples of a screw pair. (e) Spherical pair. When the two elements of a pair are connected in such a way that one element (with spherical shape) turns or swivels about the other fixed element, the pair formed is called a spherical pair. The ball and socket joint, attachment of a car mirror, pen stand etc., are the examples of a spherical pair. 2. According to the type of contact between the elements. The kinematic pairs according to the type of contact between the elements may be classified as discussed below: (a) Lower pair. When the two elements of a pair have a surface contact when relative motion takes place and the surface of one element slides over the surface of the other, the pair formed is known a lower pair. It will be seen that sliding pairs, turning pairs and screw pairs form lower pairs. (b) Higher pair. When the two elements of a pair have a line or point contact when relative motion takes place and the motion between the two elements is partly turning and partly sliding, then the pair is known as higher pair. Pair of friction discs, toothed gearing, belt and rope drives, ball and roller bearings and cam and follower are the examples of higher pairs. 3. According to the type of closure. The kinematic pairs according to the type of closure between the elements may be classified as discussed below: (a) Self closed pair. When the two elements of a pair are connected together mechanically in such a way that only required kind of relative motion occurs, it is then known as self closed pair. The lower pairs are self closed pair. (b) Force - closed pair. When the two elements of a pair are not connected mechanically but are kept in contact by the action of external forces, the pair is said to be a force-closed pair. The cam and follower is an example of force closed pair, as it is kept in contact by the forces exerted by spring		

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  DOUBLE COVER SINGLE RIVETED BUTT JOINT	Lap Joint – 4 marks (figure-2 mark, types-2 mark) Butt joint – 3 marks (types-1 mark, figure-2 mark)	
V	Advantages: 1. The welded structures are usually light in weight compared to riveted structures. This is due to the reason, that in welding, gussets or other connecting components are not used. 2. The welded joints provide high efficiency, which is not possible in the case of riveted joints. 3. Alterations and additions can be made easily in the existing structures. 4. Welded structures are smooth in appearance; therefore, it looks pleasing.	4	7

	5. A welded joint has a great strength. Often a welded joint has the strength of the parent metal itself. 6. It is easily possible to weld any part of a structure at any point. But riveting requires enough clearance. 7. The process of making welding joints takes less time than the riveted joints. 8. Shape like cylindrical steel pipes can be easily welded. But they are difficulty for riveting. 9. The welding provides very strong joints. which can't be bended easily. This is in line with the modern trend of providing rigid frames. 10. In welded connections, the tension members are not weakened as in the case of riveted joints.		
	Disadvantages: 1. For making weld joints using weld symbols requires a highly skilled labour and supervision. 2. Since there is an uneven heating and cooling in welding process during fabrication, therefore the members may get distorted or additional stresses may develop. 3. Since no provision is kept for expansion and contraction in the frame, therefore there is a possibility of cracks developing in it. 4. The inspection of defects in welding work is more difficult than riveting work.	3	
VI	In Whitworth quick return motion mechanism, the link CD forming the turning pair is fixed, as shown in figure. The link 2 corresponds to a crank in reciprocating steam engine. The driving crank CA rotates at uniform angular speed. The slider (link 4) attached to the crank pin at A slides along the slotted bar PA (link 1) which oscillates at a pivoted point D. The connected rod PR carries the ram at R to which a cutting tool is fixed. The motion of tool is constrained along line RD produced, along a line perpendicular to CD. When the driving crank CA moves from the position CA_1 to CA_2 through an angle α in clockwise direction, the tool moves from the left-hand end of its stroke to the right-hand end through a distance 2PD. When the driving crank CA moves from the position CA_2 to CA_1 through an angle β in clockwise direction, the tool moves from the	4	

	right-hand end of its stroke to the left-hand end through a distance 2PD.		
		3	
VII	Power transmitted by shaft, P = 23 kW Speed of the shaft, N = 200 rpm Load at centre of shaft, W = 900 N Length of shaft, L = 2.5 m =2500 mm Allowable shear stress, τ = 42 MPa = 42 N/mm^2 Max. normal stress, σ_b = 56 MPa = 56 N/mm^2 Let d = diameter of the shaft in mm	2	
	Torque transmitted by the shaft, $T = \frac{P.60}{2.\pi.N}$ = 955 x 10^3 N-mm Max. bending moment due to load at centre, $M = \frac{W.L}{4}$ = 562.5 x 10^3 N-mm Equivalent twisting moment, $T_e = \sqrt{M^2 + T^2}$ = 1108 x 10^3 N-mm	2	
	Equivalent twisting moment, 1108 x 10^3 = $\frac{\pi}{16}.\tau.d^3$ Solving, d 51.2 mm Equivalent bending moment, $M_e = -\left[M + \sqrt{M^2 + T^2}\right]$ = 835.25 x 10^3 N-mm Equivalent bending moment, 835.25 x 10^3 = $\frac{\pi}{32}.\sigma_b.d^3$ Solving , d = 53.4 mm	2	
	Diameter of shaft is 55 mm	1	
VIII	Diameter of shaft, D = 50 mm Torque transmitted, T = 150 N-m Extension of shaft, l = 75 mm Permissible shear stress, τ = 55 MPa = 55 N/mm^2 Permissible crushing stress, , σ_u = 110 MPa = 110 N/mm^2	2	
	Length of keyway is equal to the length of the extension of shaft Consider the shear strength of key, $T = w.l.\tau.\frac{D}{2}$ Solving, w = 1.45 mm Width is too small so adopt w = D/4 = 12.5 mm = 13 mm Also $\sigma_c = 2\tau$, so square key may use Size of square key Width, w = 13 mm, thickness, t = 13 mm, length, l = 75 mm	5	7

	Normal strength of shaft, $T = \frac{\pi D^3}{16} . \tau$ Shear strength of key, $T = w . l . \tau . \frac{D}{2}$ Shear strength of key against normal strength of shaft = $\frac{\text{Shear strength of key}}{\text{Normal strength of shaft}} = 0.99$	½	
IX	Stoke of the follower, S = 30 mm Cam rotation during outward stroke, $\varphi_a = 120^O$ Cam rotation during return stroke, $\varphi_b = 90^O$	1	7
	 (a)  (b)	3 3	
X	A coupling is a device used to connect two shafts together at their ends for the purpose of transmitting power. The primary purpose of couplings is to join two pieces of rotating equipment while permitting some degree of misalignment or end movement or both.	1	7
	Muff coupling is a type of rigid coupling, which is made up of cast iron. It is made up of a hollow cylinder with the same inner diameter as the shaft. A buried key is used to fit it over the ends of the two shafts. With the help of a key and sleeve, the transmission of power takes place from one shaft to another. 	Any 2 2 x 3	

	In flange couplings, a flange is slipped onto each of the shafts to be connected. The flanges are secured to each other through studs or bolts and onto the shaft by a key. Using set screws or a tapered key ensures that the flange hub will not slip backwards and expose the shaft interfaces.			
	Universal joint (Hooke's joint) - When two shafts aren't parallel and intersect at a small angle, we use a universal joint. This joint can accommodate small angular misalignment while providing high torque transmission capacity. The universal joint consists of a pair of hinges connected through a cross-shaft. The two hinges are positioned at 90 degrees to each other. The cross-shaft maintains this orientation and is also responsible for the power transfer. The universal joint is not a constant velocity coupling.			
	Diaphragm couplings are great all-rounder shaft couplings. They can accommodate parallel misalignment as well as high angular and axial misalignment. They also have high torque capabilities and can transmit torque at high speeds without the need for lubrication.			
	Jaw coupling is a material flexing coupling. It finds use in general low power transmission and motion control applications. It can accommodate any angular misalignment. Similar to diaphragm couplings, jaw couplings do not need lubrication. This coupling consists of two hubs with intermeshing jaws that fit into an elastomeric spider. The spider is usually made of copper alloys, polyurethane, Hyrtel or NBR and is responsible for torque transmission.			
XI	Diameter of larger pulley, $d_1 = 450$ mm Diameter of smaller pulley, $d_2 = 200$ mm Centre distance between pulleys, $C = 2$ m $= 2000$ mm		1	7

	Length of cross belt, $L_c = \pi(r_r + r_2) + \frac{(r_1+r_2)^2}{C} + 2C = 5.074$ m Where r_1 and r_2 are radii of smaller and larger pulley.	3	
	For cross belt angle of contact between the belt and each pulley is same. $\theta = 180 + 2sin^{-1}\left(\frac{r_1+r_2}{C}\right) = 198.7^O$	3	
XII	Diametrical pitch, $P_d = 0.25$ mm Module , $m = 1/P_d = 4$ mm Distance between shaft, $C = 60$ cm $= 600$ mm Speed of 1st shaft, $N_1 = 120$ rpm Speed of 2nd shaft, $N_2 = 360$ rpm	1	
	$\frac{d_1+d_2}{2} = 600$.....(1) $\frac{d_1}{d_2} = \frac{N_2}{N_1} = \frac{360}{120} = 3$.....(2) From (1) & (2) $d_2 = 300$ mm and $d_1 = 900$ mm $d_1 = mT_1$ and $d_2 = mT_2$ $T_1 = 225$ and $T_2 = 75$	6	
XIII	Gears can be classified as parallel shaft gears, intersecting shaft gears and non-intersecting non-parallel shaft gears depending on the position of their axes. Some important gears are given in detail below. Internal gear, Screw gear, Worm gear, Bevel gear, Spiral bevel gear, Spur gear, Mitre gear, Gear rack, Helical gear Internal Gear:-These gears have teeth cut on the inside part of cones and cylinders and are used to pair with external gears. These are used in shaft couplings which are of gear types and planetary gear drives. Screw Gear:- Screw gears or sometimes called crossed helical gears are helical gears used in motion transmission between non-intersecting shafts. In parallel shafts, the helical gears used have the same helix angle but in opposite directions. Worm Gear:- It consists of two elements, a screw-shaped cut on the shaft called a worm and the other one is a mating gear called a worm wheel. These two together on a non-intersecting shaft form worm gear. Mitre Gear:- These are basic bevel gears with a speed ratio of 1. The direction of power transmission is changed by them without changing speed. They can be both straight and spiral. With spiral mitre gear thrust bearing is also used as it produces thrust force in the axial direction. Bevel Gear:- These have a cone shape at their pitch surface and teeth are cut along the cone. They transmit force between two shafts that intersect at a point. Various kinds of bevel gears are helical bevel gears, spiral bevel gears, straight bevel gears, mitre gears, angular bevel gears, zero gears, hypoid gears and crowns bevel gears.	7	7

	Spiral Bevel Gear:-Bevel gears with curved tooth lines are called spiral bevel gears. They are superior to straight bevel gears in efficiency, strength, vibration and noise due to higher contact ratio but are difficult to produce. Since teeth are curved, it produces thrust force in the axial direction. Spur Gear:- Spur gears are included in the parallel shaft gear group. They are cylindrical gears having tooth lines straight and parallel to the shaft. Cylindrical gears are gears with cylindrical pitch surfaces. In meshing pairs, the larger one is called gear and the smaller one is pinion. Gear Rack:- A gear rack consists of same sized and shaped teeth cut at equal distances along a flat surface or a straight rod. It is a cylindrical gear having a radius of pitch infinity. It converts rotational motion into linear motion by meshing with a cylindrical gear pinion. Helical Gear:-These gears can transmit high loads. They are very quiet and are cylindrical gear with winding tooth lines. Its two subdivisions are left-hand twist and right-hand twist.		
XIV	The function of a differential is to transmit power from the engine to the axle that moves the wheels and allow the wheels to move at different speeds from each other. The differential has three main functions: torque transfer from the engine to the drive wheels; ensuring the wheels individual angular velocity; and together with the axle drive, serves as gear reduction unit. Proper functioning of a differential is essential while turning a vehicle. It helps in correct power distribution on left and right wheels. While a car turns on a bend, the differential ensures that the wheel on the inner side of a turning curve gets less torque than the outer one. It enhances the vehicle's control during cornering. The differential works differently while vehicles move in a straight line and when it approaches corners. 1. Vehicle going straight When the vehicle moves in a straight line, both wheels on the rear side move with an equal RPM. In this situation, all the gears, ring cage and pinions work as one unit. Axle shafts on both sides of the differential spin at a similar angular speed. As a result, both wheels cover equal distance and go straight. 2. Vehicle approaching a corner Let's assume the vehicle takes a left turn. In this situation, the left wheel has to cross a less distance than the right wheel. For this, the differential increases the rotational speed (RPM) of its right wheel to a certain extent and reduces the equivalent RPM of it's left wheel.	7	7

	A small gear placed inside the differential box rotates in order to change the speed of the large or sun gears attached to both shafts of the axle. When a car is turning leftward, the right sun gear gets more torque to increase its rotation. As a result, the vehicle conveniently bends left. This way, differentials in automobiles play a significant role in enhancing your vehicle's performance and control while cornering. It passes the right proportion of rotational speed onto both rear wheels so that your vehicle can go forward and change directions efficiently.		