

Enroll No

K.E.Society's
Rajarambapu Institute of Technology, Rajaramnagar
 (An Empowered Autonomous Institute, Affiliated to SUK)
 End Semester Examination (Nov./Dec. 2025)
 T.Y.B.Tech. Robotics & Automation Sem-V

Q.P.Code
E 1176

Course Code: RA303

Course Name: Design of Machine Elements

Day & Date: Friday 07/11/2025

Time : 10:30 To 1:30

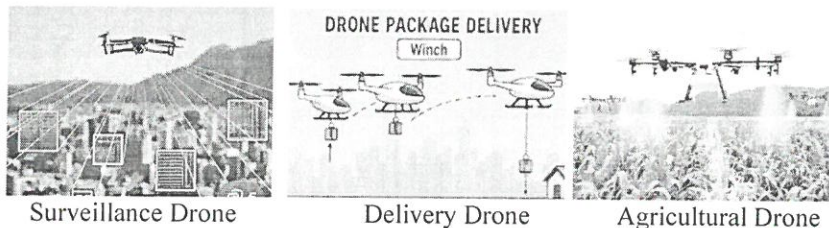
Max Marks: 100

- Instructions:**
- 1) All questions are compulsory.
 - 2) Figures in rounded () brackets within the question, indicate the scheme of marking for respective part of the question, whereas, figures in the first right column indicate total marks for that whole question.
 - 3) CO is the index number of the Course Outcome statement.
 - 4) The Bloom's taxonomy level (BL) for 1,2,3,4,5 and 6 is remember, understand, apply, analyze, evaluate and create respectively.
 - 5) Assume suitable data if necessary.
 - 6) Use of non-programmable calculators is allowed

Q.1

**Marks COs BT
Level**

- (a) Compare the maximum number of factors that you will consider while designing the following types of drones. 7 Marks CO_1 4



- (b) Discuss the aesthetic considerations in design with examples. 8 Marks CO_1 2

OR

What is factor of safety? (2 marks) Discuss the factors affecting the magnitude of factor of safety (6 marks)

Q.2

- (a) An electric motor weighing 15 kN is lifted by means of an eye bolt. The eyebolt is screwed into the frame of the motor. The eye bolt has coarse threads. It is made of plain carbon steel 30C8 ($S_{yt} = 400 \text{ N/mm}^2$) and the factor of safety is 5. Determine the size of the bolt. 5 Marks CO_2 3



Fig. 2a Eye Bolt

OR

Apply the basic stress analysis principle and discuss the simple stress analysis of bolted joint.



- (b) The structural connection shown in Fig. 2b is subjected to an eccentric force P of 10 kN with an eccentricity of 500 mm from the CG of the bolts. The centre distance between bolts 1 and 2 is 200 mm, and the centre distance between bolts 1 and 3 is 150 mm. All the bolts are identical. The bolts are made from plain carbon steel 30C8 ($S_{yt} = 400 \text{ N/mm}^2$) and the factor of safety is 2.5. Determine the size of the bolts. 10 Marks CO_2 3

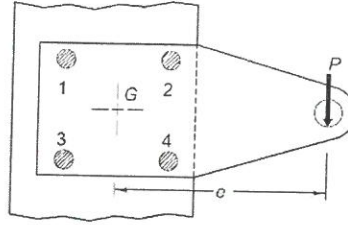


Fig. 2b Structural Connection

Q.3

- (a) The layout of transmission shaft carrying two pulleys B & C and supported on bearing A & D is shown in fig. 3a Power is supplied to the shaft by means of a vertical belt on pulley B that is then transmitted to pulley C carrying a horizontal belt. The maximum tension in belt on pulley B is 2.5 kN. The angle of wrap for both the pulleys is 180° and coefficient of friction is 0.24. The shaft is made of plain carbon steel 30C8 ($S_{yt} = 400 \text{ N/mm}^2$) and the factor of safety is 3. Determine the shaft diameter on strength basis. 10 Marks CO_3 3

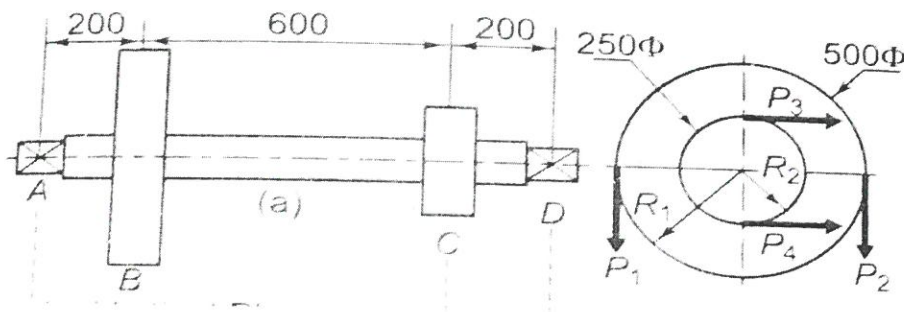


Fig. 3a Layout

- (b) It is required to design a square key for fixing a gear on a shaft of 25 mm diameter. The shaft is transmitting 15 kW power at 720 rpm to the gear. The key is made of steel 50C4 ($S_{yt} = 460 \text{ N/mm}^2$) and the factor of safety is 3. For key material, the yield strength in compression can be assumed to be equal to the yield strength in tension. Determine the dimensions of the key. 5 Marks CO_3 3

OR

Discuss the design process of square and flat shaft keys.

Q.4

- (a) Explain the criteria used for selecting various types of gears in engineering design. 6 Marks CO_4 2

OR

Explain the following problems occurred in gear teeth and give remedies for the same. i) Interference (2 marks) ii) Undercutting (2 marks) iii) Backlash (2 marks)



- (b) A planetary gear train is shown in fig. 4b. The sun gear A rotates in a clockwise direction and transmits 5 kW of power at 1440 rpm to the gear train. The number of teeth on the sun gear A, the planet gear B and the fixed ring gear C are 30, 60 and 150 respectively. The module is 4 mm and the pressure angle is 20° . Draw a free-body diagram of forces and calculate the torque that the arm D can deliver to its output shaft.

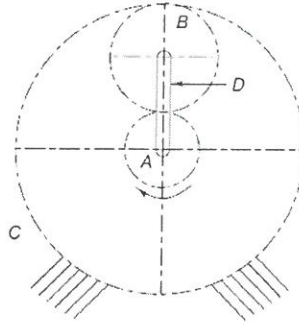


Fig. 4b

Q.5

- (a) A pair of worm and worm wheel is designated as 3/60/10/6. The worm is transmitting 5 kW power at 1440 rpm to the worm wheel. The coefficient of friction is 0.1 and the normal pressure angle is 20° . Determine the components of the gear tooth force acting on the worm and the worm wheel.

OR

A pair of worm gears is designated as, 1/30/10/8 Calculate;

- the centre distance (1 mark)
 - the speed reduction (1 mark)
 - the dimensions of the worm (2 mark) and
 - the dimensions of the worm wheel (2 mark)
- (b) Differentiate the spur gear and helical gear.
- (c) A pair of parallel helical gears consists of a 20 teeth pinion meshing with a 100 teeth gear. The pinion rotates at 720 rpm. The normal pressure angle is 20° , while the helix angle is 25° . The face width is 40 mm and the normal module is 4 mm. The pinion as well as the gear is made of steel 40C8 ($S_{ut} = 600 \text{ N/mm}^2$) and heat treated to a surface hardness of 300 BHN. The service factor and the factor of safety are 1.5 and 2 respectively. Assume that the velocity factor accounts for the dynamic load and calculate the beam strength (4 marks) and wear strength (4 marks) of the gear.

Linear interpolation formula:

$$y = y_1 + (x - x_1) \frac{(y_2 - y_1)}{(x_2 - x_1)}$$



OR

Identify type of lever shown in following figures. Justify your answer.

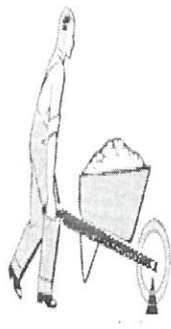


Fig. i.



Fig. ii.

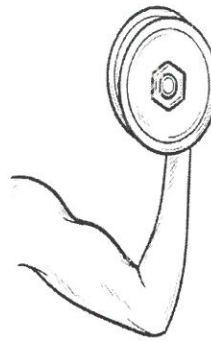


Fig. iii.

- (b) A helical compression spring, made of circular wire, is subjected to an axial force, which varies from 2.5 kN to 3.5 kN. Over this range of force, the deflection of the spring should be approximately 5 mm. The spring index can be taken as 5. The spring has square and ground ends. The spring is made of patented and cold-drawn steel wire with ultimate tensile strength of 1050 N/mm² and modulus of rigidity of 81370 N/mm². The permissible shear stress for the spring wire should be taken as 50% of the ultimate tensile strength. Design the spring and calculate:
- (i) wire diameter (1 marks)
 - (ii) mean coil diameter (1 marks)
 - (iii) number of active coils (2 marks)
 - (iv) total number of coils (2 marks)
 - (v) solid length of the spring (2 marks)
 - (vi) free length of the spring (2 marks)
 - (vii) required spring rate (2 marks)
 - (viii) actual spring rate (2 marks)

14 Marks CO_5

3

Wahl factor Equation:

$$K = \frac{4C - 1}{4C - 4} + \frac{0.615}{C}$$

Refer following tables if required.

Lewis form factor Table

z	Y	Z	Y	z	Y
15	0.289	32	0.364	150	0.458
16	0.295	33	0.367	200	0.463
17	0.302	35	0.373	300	0.471
18	0.308	37	0.380	Rack	0.484
19	0.314	39	0.386		
20	0.320	40	0.389		
21	0.326	45	0.399		
22	0.330	50	0.408		
23	0.333	55	0.415		
24	0.337	60	0.421		
25	0.340	65	0.425		
26	0.344	70	0.429		
27	0.348	75	0.433		
28	0.352	80	0.436		
29	0.355	90	0.442		
30	0.358	100	0.446		

