FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGERIA
SCHOOL OF ELECTRICAL ENGINEERING AND TECHNOLOGY
DEPARTMENT OF MECHATRONICS ENGINEERING
SECOND SEMESTER 2018/2019 B.Eng. DEGREE EXAMINATION
COURSE: MCE 321 Design of Machine Elements.

INSTRUCTION: Attempt two questions from each section.

TIME ALLOWED: 3 HOURS

SECTION A.

Q1. (a) Differentiate between backlash and fundamental law of gearing with aid of supporting diagrams and hence explain the effect of backlash on service life of gear trains made of tool steel. **[5 Marks]**

(b) Show with aid of appropriate diagram, the working principle of rack and pinion gear, and its application in an automobile's door mechanism. **[5 Marks]**

(c) Differentiate between rolling gear and compound gear respectively; use diagrams to buttress your point. **[5 Marks]**

Q2. A system of gears A, B and C constitutes a gear train. Gear A was supplied 8 KW power at 900 rpm via its shaft which rotates in a clockwise direction. Gear B is an idler gear, whereas gear C is the driven gear. The number of teeth gear A has is 80 teeth, B has 120 teeth and C has 90 teeth respectively. All the gears have same module value of 10 mm.

Determine:

(i) Torque on each gear shaft. **[3 Marks]**
(ii) The components of gear tooth force. **[2 Marks]**
(iii) Sketch the free-body-diagram of forces on the system of gears. **[8 Marks]**
(iv) Calculate the reaction on the idler gear shaft, assume 22º involute for the gears. **[2 Marks]**

Q3. (a) Towards development of a prototype compression helical spring to support 2,500 N load, the corresponding deflection is to be 50 mm at spring index of 6. The ultimate tensile strength and modulus of rigidity of the spring material are 1090 and 83500 N/mm^2 respectively. The permissible shear stress for the spring wire is taken to be 60% of the ultimate tensile strength.

Calculate:

(i) Wire diameter. **[2 Marks]**
(ii) Mean coil diameter. **[2 Marks]**
(iii) Number of active coils. **[2 Marks]**
(iv) Total number of coils. **[2 Marks]**
(v) Free length of the spring. **[2 Marks]**
(vi) Pitch of the coil. **[2 Marks]**

(b) Sketch a helical spring in compression mode, and mention where in the chassis of a train's coach or wagon it is situated. What purpose does it fulfill in a train's chassis? **[3 Marks]**

SECTION B.

Q4a). From first principle derive the principal stress equations 1 and 2 for a stress at a point in body. **[8 Marks]**

b). The state of plane stress at a point extracted from a component in a moving mobile robot is represented by the stress element below. Determine the principal stresses and their angles. **[7 Marks]**

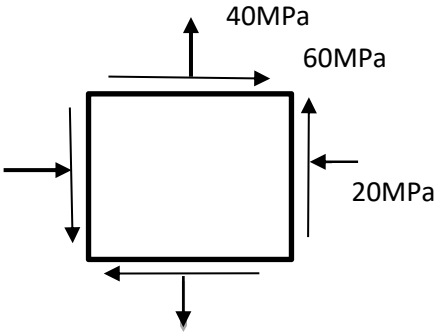

Figure 1

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^{\ 2}}$$

$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

Q5a). An elemental part shaft of a moving robot subjected to combined stresses is expanded as shown in figure 2. Determine using Morh's circle method: **[7marks]**

i. The principal planes.
ii. The principal stresses.
iii. The maximum shear stress and the corresponding normal stress.

b). Part of a simply supporting structure of a robotic arm is subjected to two point loads shown in figure 3. Determine the maximum shear force and bending moment. And plot them. **[8 Marks]**

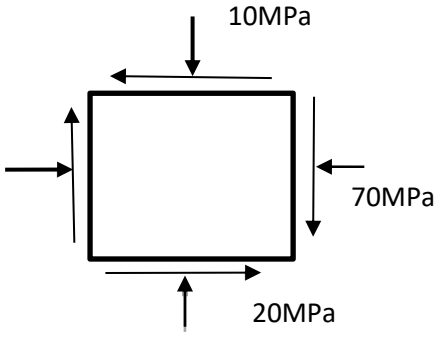

Figure 2

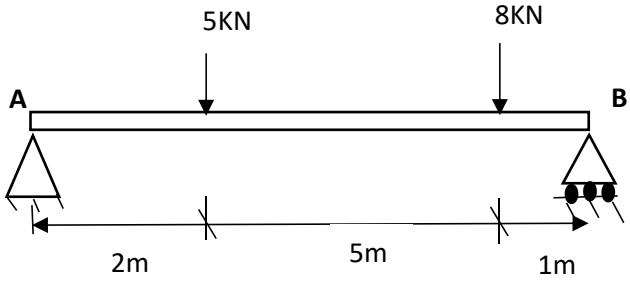

Figure 3

Q6a). A steel rod and two copper rods together support a load of 370KN as shown figure 4. The cross sectional area of steel rod is 2500mm^2 and of each copper is 1600mm^2. Find the stresses in the rod. Take E for steel =2 x 10^{5}N/mm^2 and for copper =1 x10^{5}N/mm^2. **[9Marks]**

b). A cast iron link as shown in figure 5 is required to transmit a steady tensile load of 60KN. Find the tensile stress induced in the link material at sections A-A and B-B. **[3Marks]**

c). A circular hollow tube made of steel is used to support a compressive load of 500kN. The inner and outer diameters of the tube are 90mm and 130mm respectively and its length is 1000mm. Due to compressive load, the contraction of the rod is 0.5mm. Determine the compressive stress and strain in the post. **[3Marks]**

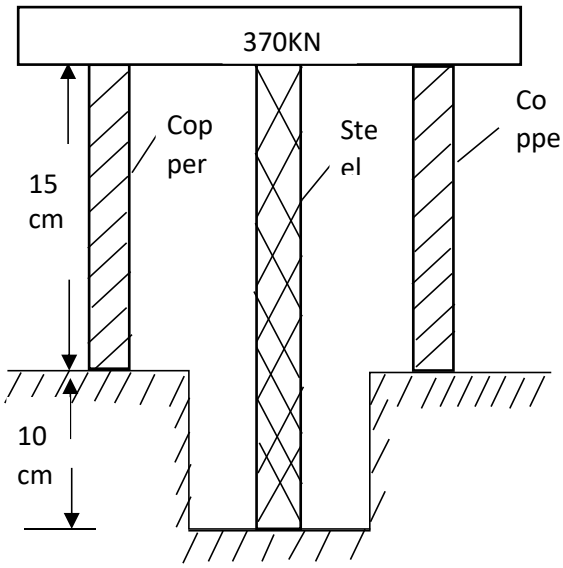

Figure 4

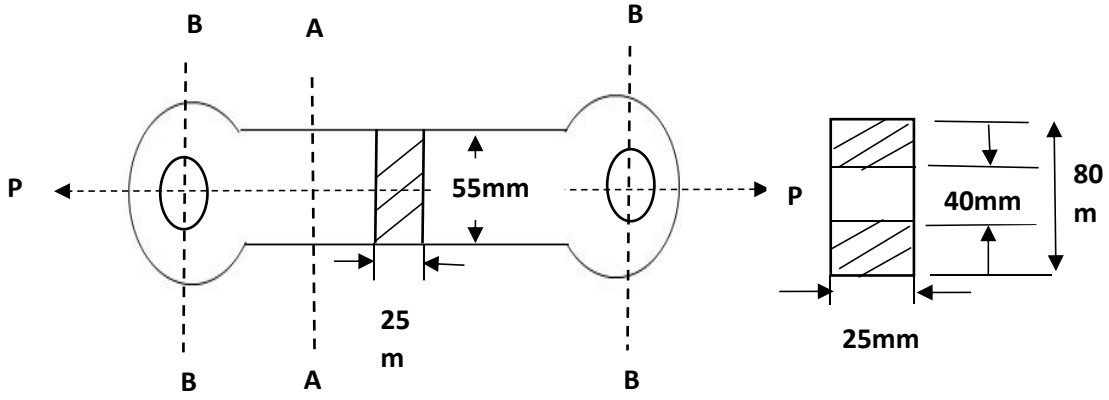

Figure 5