B.E. MECHANICAL ENGINEERING 2nd YEAR 1st SEMESTER EXAMINATION, 2019

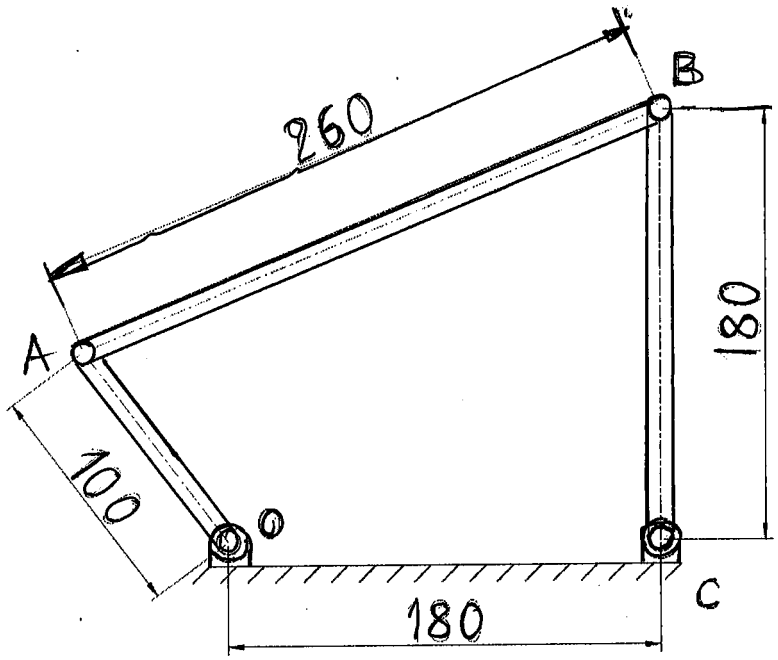
ENGINEERING MECHANICS- III

Time: 3.0 Hrs. **Full Marks: 100**

[Assume missing data, if any, in the questions with suitable justifications. Draw the Free Body Diagram (FBD)s wherever applicable.]

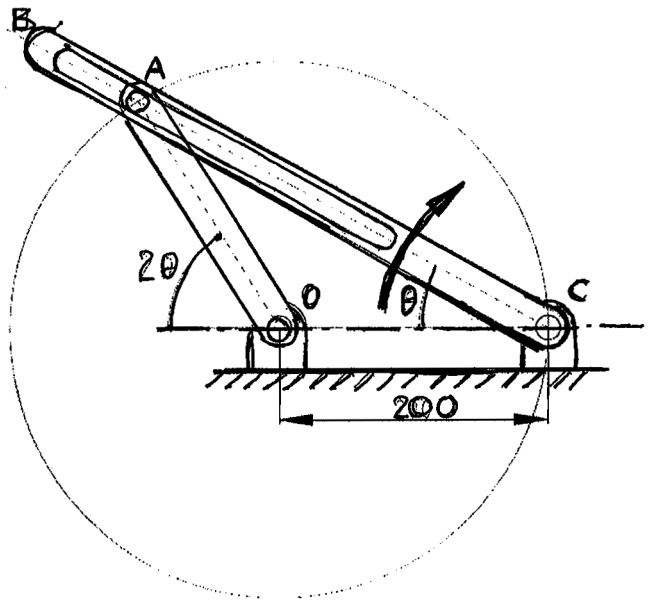
GROUP – A (Answer Any *One* Question)

Q1. In a four-bar linkage **OA** has a constant counter-clockwise angular velocity $\omega_0 = 10 rad/s$, calculate the angular acceleration of link **AB** for the position where the coordinates of **A** are $x = -60mm$ and $y = 80mm$. Link **BC** is vertical for this position. Also calculate the magnitudes of velocity and acceleration of point **B** of the mechanism. Refer to **FigQ1**. **25**



FigQ1 (Dimensions in mm)

Q2. The crank **OA** revolves clockwise with a constant angular velocity of $10 rad/s$ within a limited arc of its motion. For the position $\theta = 30°$ determine the angular velocity of the slotted link **CB** and the acceleration of **A** as measured relative to the slot in **CB**. Refer to **FigQ2.** **25**



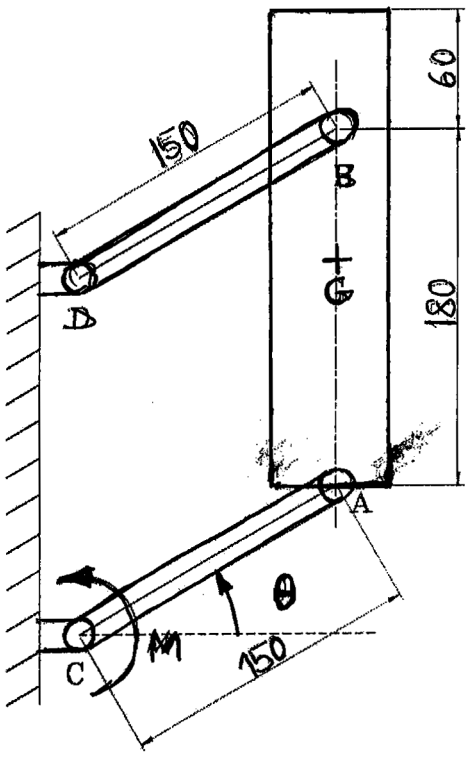
FigQ2 (Dimension in mm)

GROUP – B (Answer Any *One* Question)

Q3(a) The vertical uniform bar **AB** has a mass of **15kg** with centre of mass **G** midway between the ends. The bar is elevated from rest at $\theta = 0$ by means of the parallel links of **negligible mass,** with a constant couple ***M*=5kN.m** applied to the lower link at **C**. Determine the angular accelerations α of the links as a function of θ and find the force in the link **DB** at the instant when $\theta = 30^0$. Refer to **FigQ3(a)** **12**

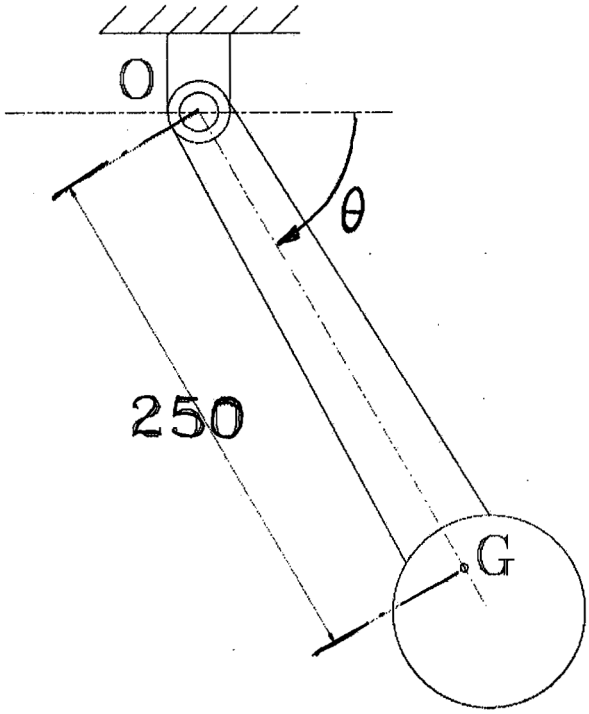
(b) The pendulum has a mass of **7.5 kg** with centre of mass at **G** and has a radius of gyration about the pivot **O** of **295mm**. If the pendulum is released from rest at $\theta = 0$, determine the total force supported by the bearing at the instant when $\theta = 60^0$. Friction in the bearing is negligible. Refer to **FigQ3(b)** **13**

[Please refer to the next page for the figures of the above problems]



FigQ3(a)

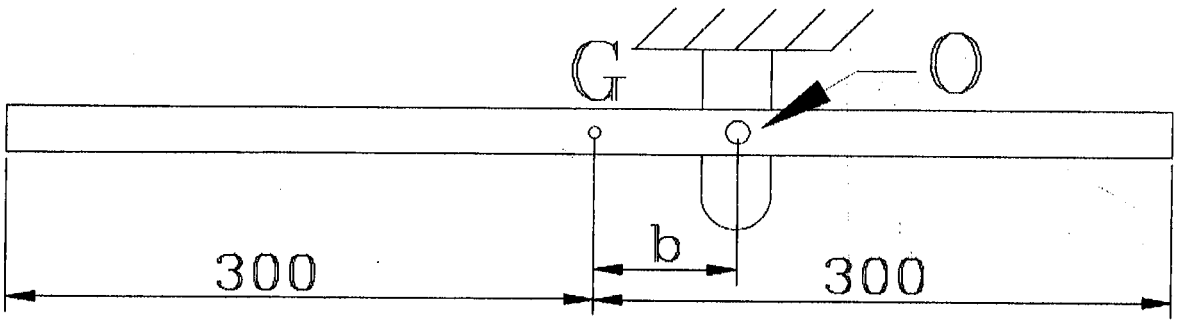
(Dimension in mm)



FigQ3(b)

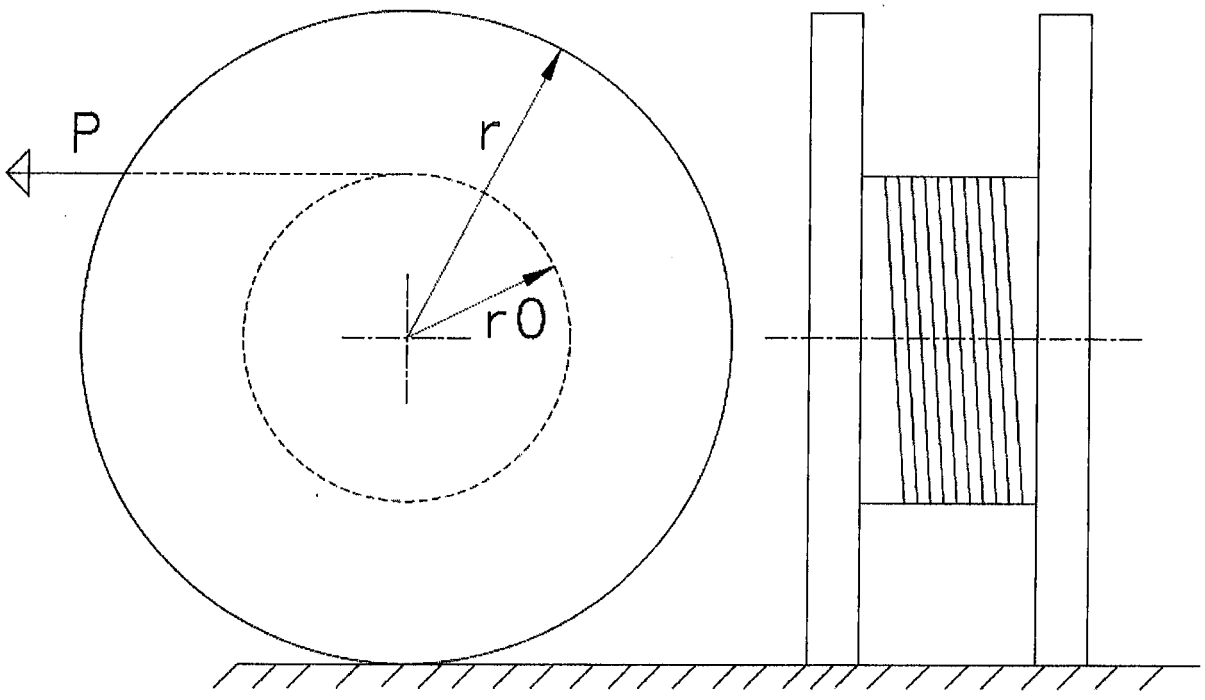
(Dimension in mm)

Q4(a) The uniform **8.0 kg** slender bar is hinged about a horizontal axis through **O** and released from rest in the horizontal position. Determine the distance b from the mass centre **G** to **O** which will result in an initial angular acceleration of $16\ rad/s^2$ and find the force R on the bar at **O** just after release. Refer to **FigQ4(a)** **12**



FigQ4(a) (Dimension in mm)

(**b**) What should be the radius r_0 of the circular groove in order that there will be no friction force acting between the wheel and the horizontal surface regardless of the magnitude of the force ***P*** applied to the cord? The radius of gyration of the wheel about the centre of mass is k_0. Refer to **FigQ4(b)**. **13**



FigQ4(b)

GROUP – C (Answer Any *One* Question)

Q5(a) Consider an Aluminum tubular (Outer diameter = **32 mm**, wall thickness = **4.0 mm**) column of length **2.0 m** which is **fixed** at one end and **pinned** at the other, with a centrally applied compressive load of magnitude P_0. Assuming E = **70 GPa** and considering factor of safety **2.3** against bucking, calculate the safe value of the load P_0. **5**

(b) Consider a long prismatic column being **fixed** at one end and **free** at the other end. An axial compressive load P is applied to the column at its free end with its line of action at distance of e from the centroidal axis of the column member.

(i) Deduce an expression for the maximum compressive stress that is induced in the column.

(ii) Can you determine the critical load for the column from your derivation?

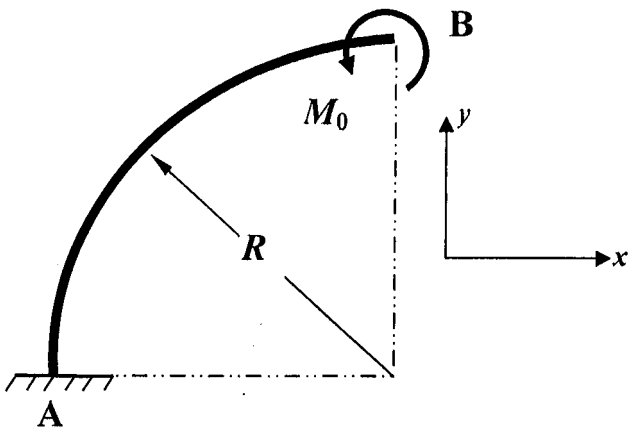
(iii) If the above type of column (i.e., one end **fixed** and the other end **free**) having **100 mm** ×**100 mm** cross-section with **4.0 m** length is subjected to a compressive force of **100 KN**, then calculate the maximum permissible eccentricity of the line of action of the 100 KN load so that the maximum compressive stress induced in the column never exceeds **100 MPa**.

9+3+8=20

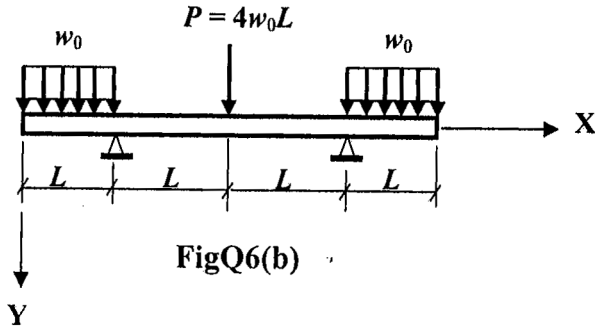
Q6(a) Refer to the curved cantilever beam **AB** as shown in **FigQ6(a)** subjected to a moment M_0 at its free end. Calculate the x and y components of displacements of the point **B** of the beam. Assume flexural rigidity of the beam to be constant. Consider only deformation due to bending. Draw appropriate free body diagram of the beam while answering.

Apply ***Castigliano's*** appropriate theorem to solve your problem. **10**

FigQ6(a)



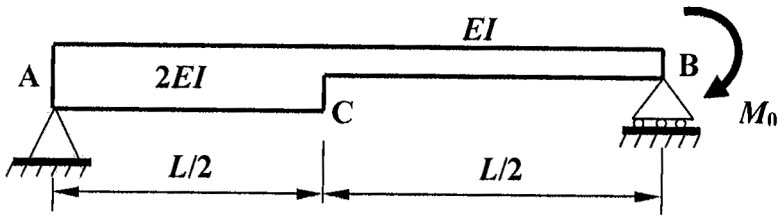
(b) Apply the concept of **singularity function** to find the equation of the elastic line of the beam shown in **FigQ6(b)**. Also find the maximum deflection of the beam. Assume ***EI*** constant for the beam. **10+5=15**



FigQ6(b)

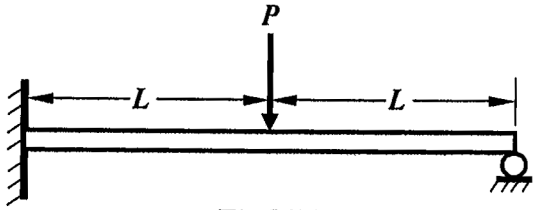
GROUP – D (Answer Any *One* Question)

Q7(a) Apply the **moment-area theorems** to find the slopes at end **A** and **B** of the elastic line and the vertical deflection of point **C**. **3+3+4= 10**



FigQ7(a)

(b) Find the support reactions and moment for the propped cantilever beam as shown in the following figure. **15**



FigQ7(b)

Q8 (a) FigQ8 shows cross-sectional view of a reinforced concrete beam with all necessary details. If the maximum bending moment of the beam is + **200.0 kN·m**, then answer the following:

i) Draw giving all necessary dimensional details, the equivalent transformed section considering the beam to be made up of concrete.

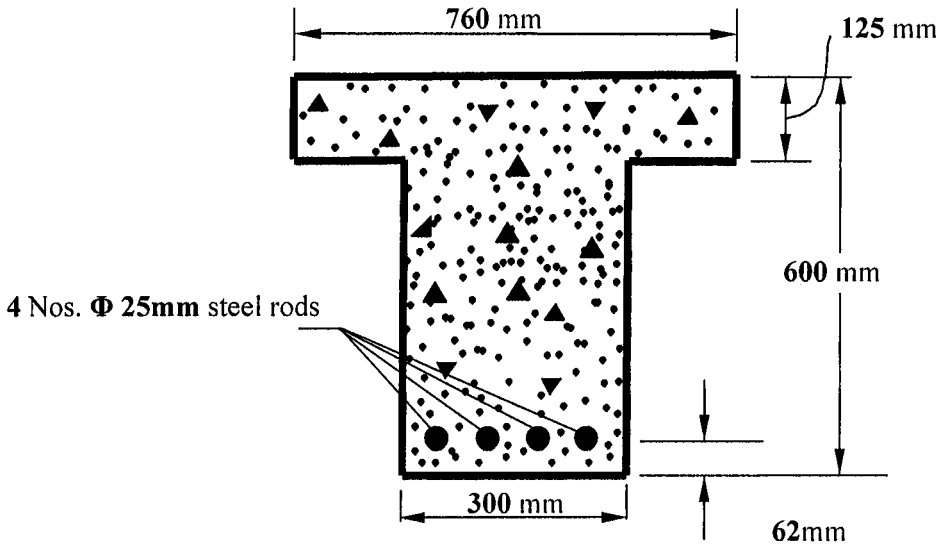
ii) Locate the neutral axis of the cross-section.

iii) Calculate the area moment of inertia of the equivalent section about its neutral axis.

iv) Calculate the maximum stress in concrete (give your answer in **MPa**).

v) Calculate the maximum stress in **steel** (give your answer in **MPa**).

Consider Young's modulii of elasticity of concrete and steel as **25 GPa** and **200 GPa** respectively. **20**



FigQ8(a)

(**b**) What do you mean by "**balanced reinforced concrete beam**"? **5**