Exam of Engineering Mechanics and Mechanics of Materials

Note: There are two parts in this exam: engineering mechanics (dynamics) and mechanics of materials. Each part includes three problems. You have to solve *at least two problems* in each part; otherwise, the fifth problem you solve will not be counted.

Part 1: Engineering Mechanics (Dynamics)

Problem #1 Consider a particle *P* *moving* in x-y plane as shown in figure 1. If the position vector of *P* refer to coordinate system x-y is expressed as $\vec{R} = ze^{iq}$, (1) derive the velocity and acceleration of *P*; (2) explain the physical meaning of each term in the acceleration. (3) If OP is a rigid link and O is a revolute joint, which term in the acceleration will disappear? (18%)

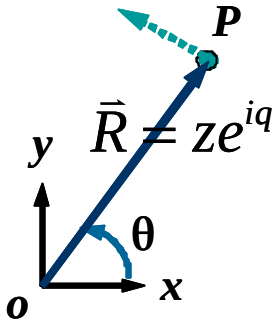

Figure 1

Problem #2 The bag A, having a weight of 3 kg, is released from rest at the position $q = 0^o$, as shown in figure 2. After falling $q = 90^o$, it strikes a 9 kg box B. If the coefficient of restitution between the bag and box is $e = 0.5$, (1) determine the velocities of the bag and box just after impact and (2) determine the loss of energy during collision. (16%)

Solution:

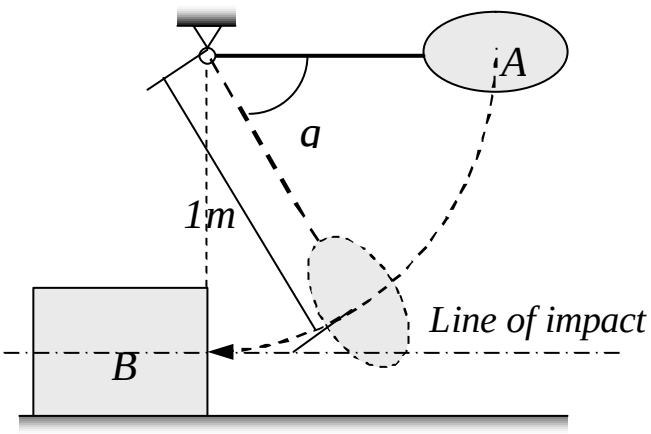

Figure 2

Problem #3 The smooth 2-kg cylinder *C* in figure 3 has a peg *P* through its center which passes through the slot in arm *OA*. If the arm rotates in the vertical plane at a constant rate $\dot{q} = 0.5$ (rad/s), determine the force that the arm exerts on the peg at the instant $q = 60^o$. (16%)

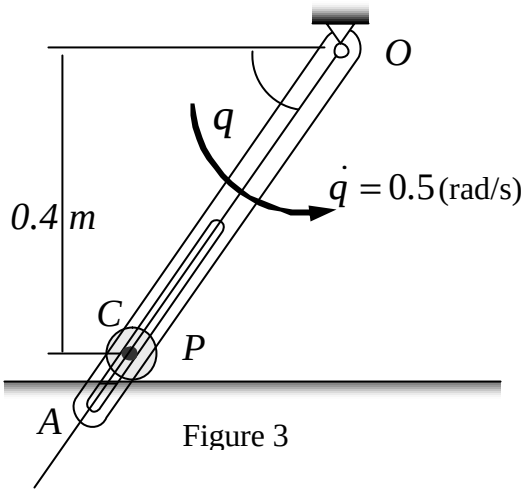

Figure 3

Part 2: Mechanics of Materials

Problem #4 A rigid bar *ABCD* is pinned at the end A and supported by two cables at points *B* and *C*. The effective areas at the cables *B* and *C* are given $A_B = 76.7\ mm^2$ and $A_C = 173\ mm^2$. The ultimate loads for cables B and C are given $(T_B)_{ult} = 102\ kN$ and $(T_C)_{ult} = 231\ kN$. A load *P* acts at end *D* of the bar as shown in the figure 4. What is the allowable load *P* if the temperature rises by 60^oC and each cable is required to have a factor of safety of at least 5 against its ultimate load ? (Note: the cables have the elastic modulus *E=140 GPa* and coefficient of thermal expansion $\alpha = 12 \times 10^{-6}/^oC$) (16%)

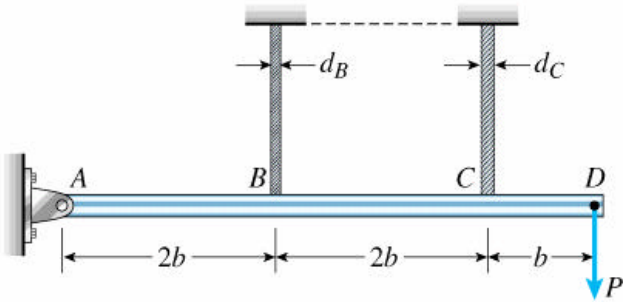

Figure 4

Problem #5 The simple support beam AB shown in the figure 5 is subjected to a concentrated load *P* and a couple $M_1 = PL/4$ acting at the third points. (1) Draw the shear-force and bending-moment diagrams for this beam. (2) If P = 360 kN, L = 10 m, and the dimensions of the cross section are given in the figure 5, calculate the maximum principle stress and maximum shear stress along the beam, and (3) draw its Mohr's circle for the point. (18 %)

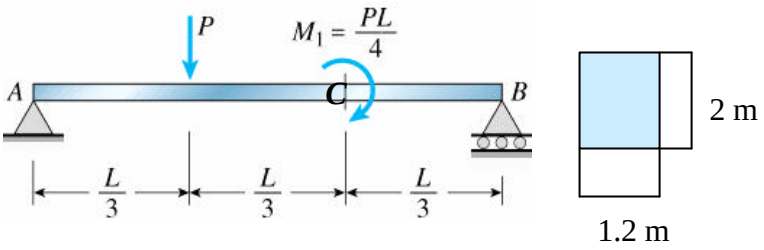

Figure 5

Problem #6 A stress-strain curve of a structural steel is shown in figure 6. Explain the physical meaning of each section and each point at the solid line and the dash line. (16%)

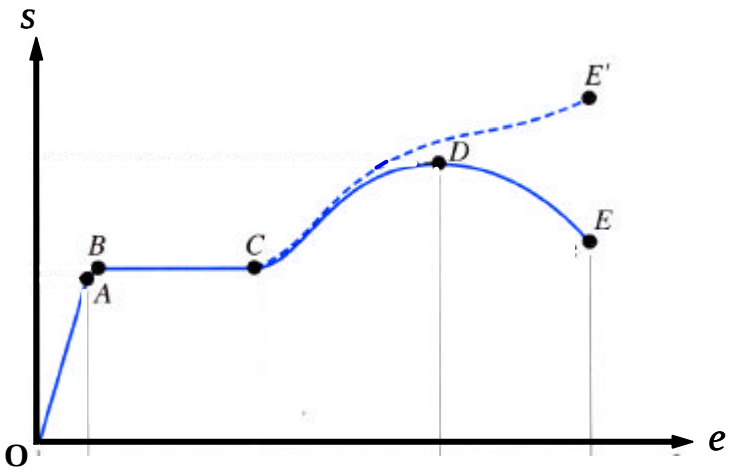

Figure 6