**APL 100 Engineering Mechanics**

**Major (PART B)**

Answer all questions for this part in the **separate answer sheet.** Each question carries ten marks; total marks for this part = 60.

**Q. 1:** A bead C of mass $m$ moves over a parabolic rod ED (Figure **Q. 1**). The radius of curvature of parabola at the position of C is $\rho$ and its coefficient of friction is $\mu$. C moves with respect to the rod at speed $v$ which is increasing at unknown rate $a$. Find the normal force $N$ from the rod on the bead and $a$.

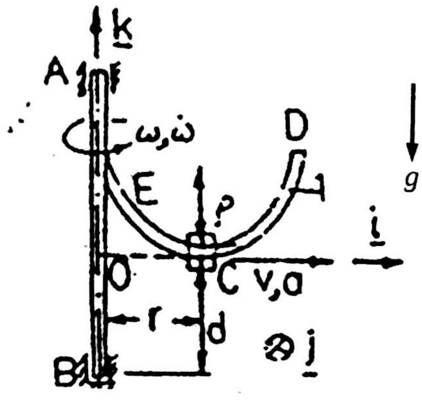


Figure **Q.1**

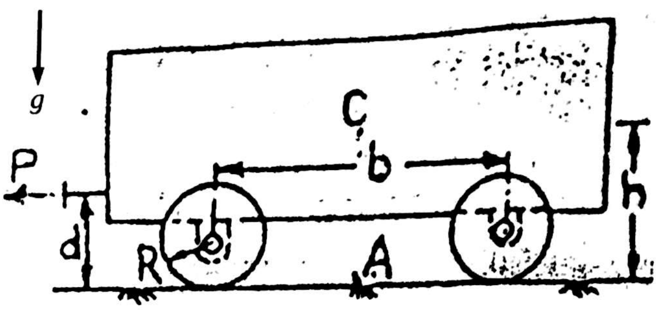


Figure **Q.2**

**Q. 2:** A railway wagon of total mass $M$ has its centre of mass at height $h$ above the tracks (Figure **Q. 2**). The mass of all wheels is $m$. Each wheel has radius $R$ and radius of gyration $k$ about the axis of symmetry. Assume that wheels roll without slip on the railway track. Find the location $d$ of the coupling mechanism such that the load on the front and rear axles is the same when the train has acceleration $a$. Express your answer in terms of $M$, $m$, $R$, $h$, $k$. It will be helpful to draw the FBDs of any one (rear/front) wheel and translating wagon, write equations of motion and solve for $d$.

**Q. 3:** The crank OA in Figure **Q. 3** has radius of gyration $k_o$ about its axis of rotation at O. The moment of inertia of the connecting rod AB about an axis through its centre of mass C normal to its vertical plane of motion is $m_2 k_c^2$. Consider all the joints/contacts as frictionless. (a) Using the rate form of the work energy relation, find the initial angular acceleration of the crank. (b) Using work energy relation, find the constant driving moment ($M_1$) to be applied to the crank so that it has angular velocity $\omega$ after a rotation of $\pi/2$ starting from rest.

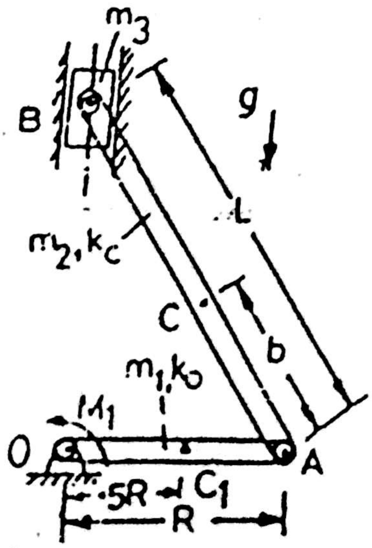


Figure **Q.3**

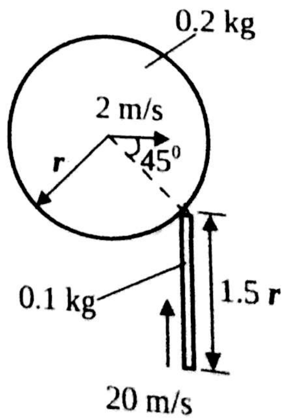


Figure **Q.4**

**Q. 4:** An arrow moving at 20 m/s hits a disc translating at 2 m/s (Figure **Q. 4**). Find the angular velocity of the arrow just after impact if the impact is smooth with e = 0.3.

**Q. 5:** Draw the shear force and bending moment diagrams for the beam shown in Figure **Q. 5**. Take $P = 5q_oL/6$ and $M_o = q_oL^2/6$.

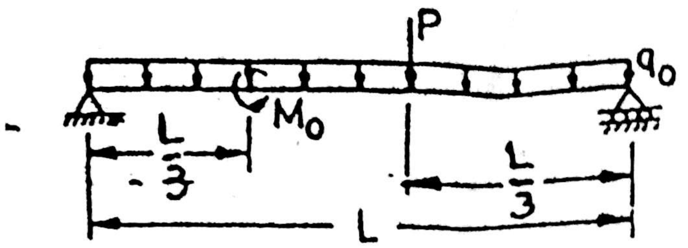


Figure **Q. 5**

**Q. 6:** Two sliders are pinned at A and C to a uniform rod AB of length $2L$ and mass $m$ (Figure **Q. 6**). The resisting force on slider 1 is $cv_C$ ($v_C$ is the velocity of slider C and $c$ is a constant) and on slider 2 is **P**. The spring is unstretched for $\theta = 0$. Using $\theta$ as the generalized coordinate, set up Lagrange's equation of motion.

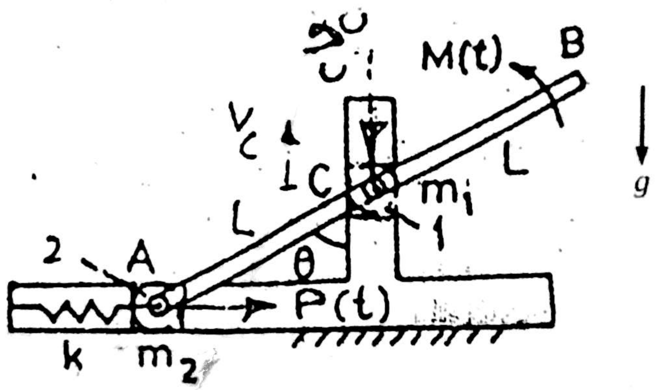


Figure **Q. 6**