

INDIAN INSTITUTE OF TECHNOLOGY

Date: .09.2012 (day F/N) Autumn Semester Time: 2 hrs Full Marks: 60

Subject Name: Dynamics

Subject No.: ME20001

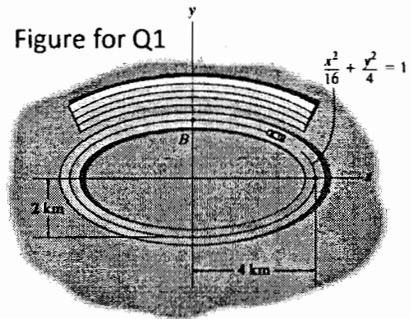
No of students: 180 (approx) 2nd Year B. Tech +DD (ME+MF) +Breadth+Addl

Question paper has 2 pages (back to back).

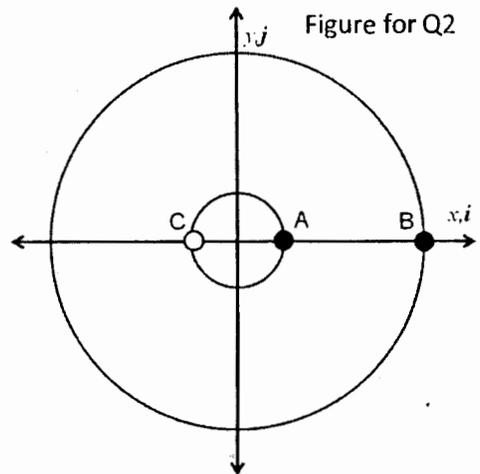
All questions carry equal marks. Answer any 2 questions from page 1 and any 2 questions from page 2. Any assumptions made in solving the questions should be justified with reasons.

$g = 9.81 \text{ m/s}^2$

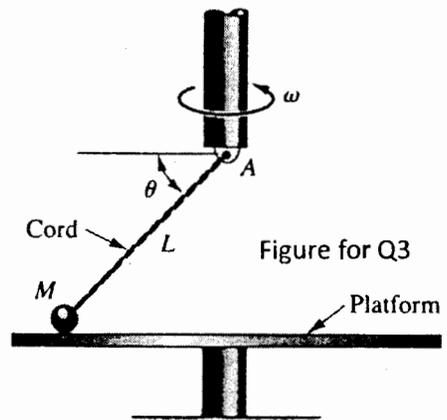
1. A racing car travels with a constant speed of 240 kph around the elliptical race track. Determine the acceleration experienced by the driver at A and B. Equation of the ellipse is $x^2/16 + y^2/4 = 1$ where x and y are in km.



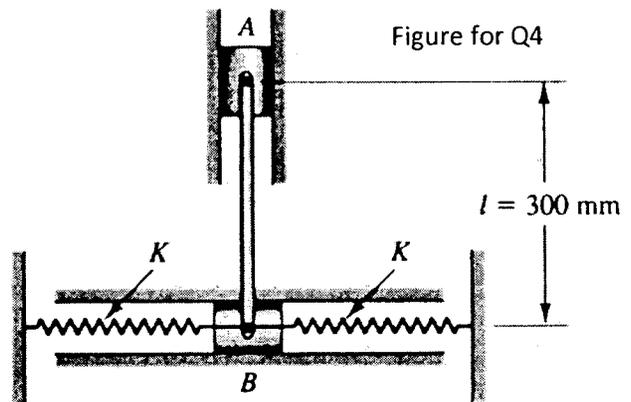
2. Two satellites move in concentric circular orbits of radius r and 4r around the earth, but in opposite directions. Assume both satellites were collinear with the earth and were closest to each other when they were put into the circular orbit, i.e. inner satellite was at A and outer satellite was at B. The inner satellite has a velocity v in its orbit. What is the relative velocity of the inner satellite with respect to the outer satellite in the coordinate system shown when it reaches point C? What is the relative acceleration of the inner satellite with respect to the outer satellite in the coordinate system shown when it reaches point C? What is the radius of curvature of the orbit of the inner satellite, as observed from the outer satellite, when the inner satellite is at point C?



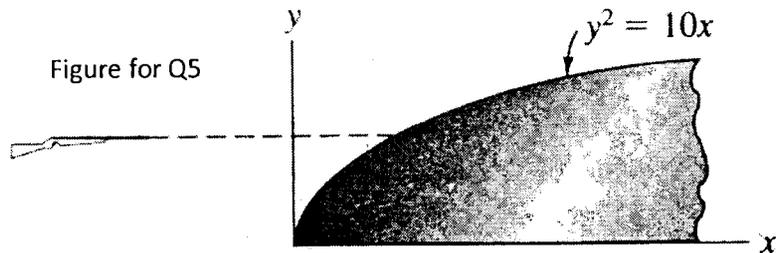
3. A mass M is swinging around a vertical axis at the end of a weightless cord of length L. M is supported by a frictionless platform that can be moved vertically upward from its lowest position, where it just touches M. Formulate an equation giving the tension T in the cord in terms of M, L and ω . What is the value of θ at which the platform first ceases to touch M as the platform is moved down from its highest position ($\theta=0$)?



4. Masses A and B, each having a mass of 75 kg, are constrained to move in frictionless slots. Also there is no friction in the end connections of the rod. A and B are connected by a light rod of length $l = 300$ mm. Mass B is connected to two massless linear springs each having a spring constant $K = 900$ N/m. The springs are unstretched when the connecting rod to masses A and B are vertical. What are the velocities of B and A when A descends a distance of 25 mm?



5. A bullet hits a smooth, hard, infinitely massive two dimensional body whose boundary is a parabola of the form $y^2 = 10x$, where x, y are in m, in the coordinate system shown. If the bullet strikes the parabola at 1.5 m above the x axis in a direction parallel to the x axis with a velocity of 77m/s and if the coefficient of restitution is $e=0.6$, where does it hit the parabola again?



6. A space station is in a circular orbit about the earth 500 km above the earth's surface. A space shuttle on the space station is fired from the space station with a speed of 800 kph relative to the space station in the opposite direction to that of the space station. Assume that the firing takes place instantaneously and does not affect the motion of the space station. What speed will the space shuttle have when it enters the earth's atmosphere at about 50 km above the earth's surface? Radius of the earth is 6400 km. $GM=5.16 \times 10^{12}$ km³/hr².

