Menofia University
Faculty of Engineering Shebin El-kom
Basic Engineering Sci. Department.
First semester Examination, 2013-2014
Date of Exam : 13 /1/ 2014

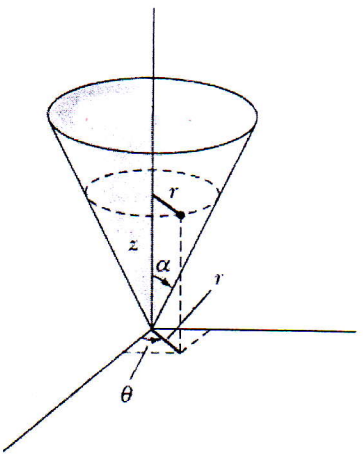
Subject: Analytical Mech.
Code: BES 620
Year : Master
Time Allowed : 3 hrs
Total Marks: 100 Marks

Answer only four questions of the following

Question 1 (25 MARKS)

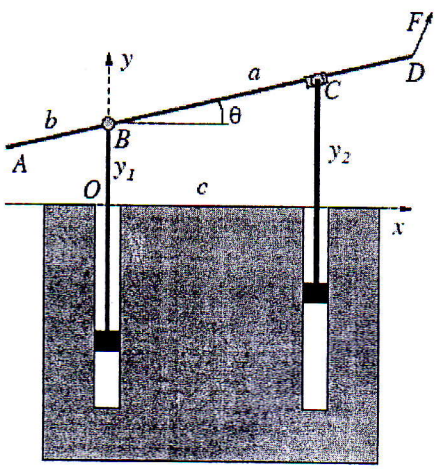
(A)

Suppose that a particle with mass m is moving in a vertical cone with opening angel α as shown in the figure. Describe the motion by computing θ *and* z using Lagrange's equations.



(B)

A rod AD is steered by a machine. The machine has two shafts connected by rotatory joints to the rod at A and B. The machine can move the rod by moving its shafts vertically. The joint at A is attached to a fixed point of the rod, at distances a and b from its endpoints, see figure. The joint at C can slide along the rod so that the horizontal distance between the joints, c, is kept constant. Use as generalised coordinates for the rod the y-coordinates y_1 and y_2 of the joints. Determine the generalised force components of the force $\vec{F} = F_x\hat{x} + F_y\hat{y}$.

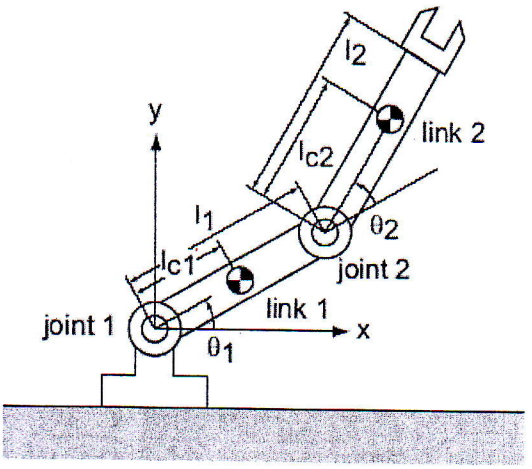


Question 2 (25 MARKS)

(A) Derive Lagrange's equations of motion from the principle of least action using elementary calculus. Also, demonstrate the conditions under which energy and momentum are constants of the motion.

(B)

For open link mechanism, formulate kinetic and potential energies apply Lagrange's equations of motion.



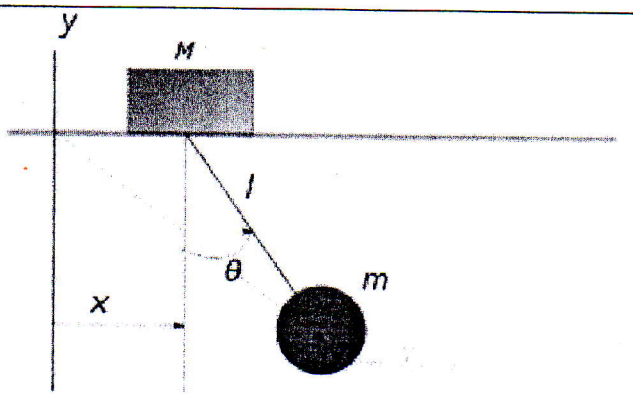
Question 3 (25 MARKS)

(A) Suppose that a particle with mass m is constrained to move on a cylinder with central force $\vec{F} = -k\, r\, \vec{r}$ where r is the radius of the base of the cylinder. Describe the equations of motion by computing $z(t)$ *and* $\theta(t)$.

(B)

Consider a pendulum of mass m and length ℓ, which is attached to a support with mass M which can move along a line in the x-direction. Let x be the coordinate along the line of the support, and let us denote the position of the pendulum by the angle θ from the vertical.

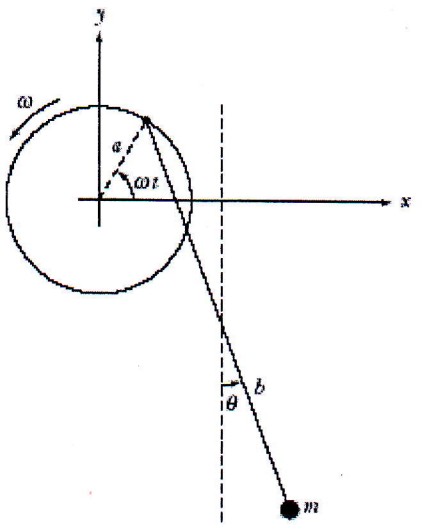
Describe the kinetic energy, potential Energy, Lagrangian and find the equation of motion



Question 4 (25 MARKS)

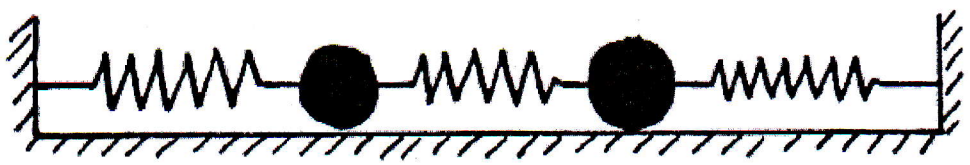
(A)

Support of pendulum has a length b and mass m are connected with a fixed rotating disk with radius a and angular velocity ω as shown in the figure. Use Euler-Lagrange equations to describe the motion of the pendulum mass.



(B)

Two masses are connected with a spring, and each is connected with a spring to a fixed point. Find the equations of motion, and describe the motion qualitatively. Solve for the possible angular frequencies in the case when the masses are equal and the spring constants are equal. There is no friction.



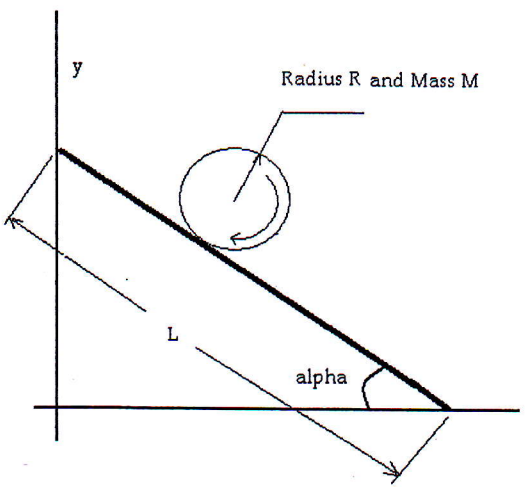
Question 5 (25 MARKS)

(A)

Suppose that a disk with mass M is rolling down on an inclined plane with length L and an angle α (alpha) As shown in the figure. The angular velocity of the disk is $\omega = \dot{\theta}$.

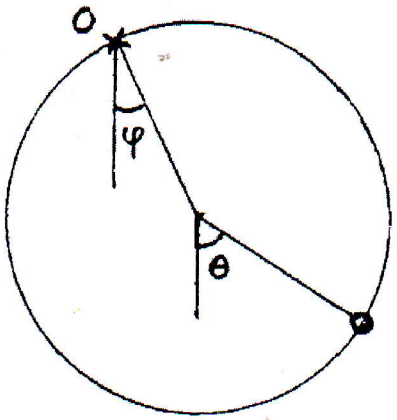
Use Euler-Lagrange's equation to describe the Motion of the disk with constraint

$g(y,\theta,t) = y - R\theta = 0$.



(B)

A small bead of mass m is sliding on a smooth circle of radius a and mass m which in turn is freely moving in a vertical plane around a fixed point O on its periphery. Give the equations of motion for the system, and solve them for small oscillations around the stable equilibrium. How should the initial conditions be chosen for the system to move as a rigid system? For the center of mass not to leave the vertical through O?



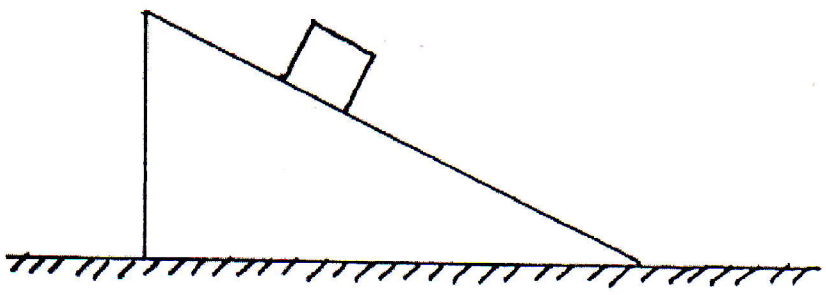
Question 6 (25 MARKS)

(A) ***Use Lagrange's equations to***

Find the equations of motion for a particle moving on an elliptic curve $(\frac{x}{a})^2 + (\frac{y}{b})^2 = 1$ using a suitable generalized coordinate. Check the case when $a = b$.

(B) ***Do this problem using Lagrange's equations***

A particle of mass m is sliding on a wedge, which in turn is sliding on a horizontal plane. No friction. Determine the relative acceleration of the particle with respect to the wedge.



This exam measures the following ILOs											
Question Number	Q1-a	Q2-b	Q6-b	Q5-a	Q5-b	Q3-b	Q4-a		Q1-b	Q3-a	Q4-b
Skills					Q2-a				Q6-a		
	Knowledge &understanding skills				Intellectual Skills				Professional Skills		

With my best wishes

Dr. Islam M. Eldesoky