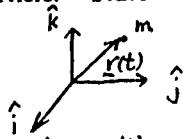
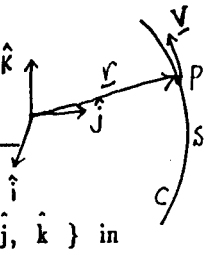
PART I.(Answer the following problems carefully)

(A) (3%)Given a reference frame { $\hat{i}$, $\hat{j}$, $\hat{k}$ }, a particle of mass m has position $\underline{r}(t)$. Let $\underline{F}(t)$ be the total force acting on the particle. State Newton's Second Law completely.



(B) (3%)Intrinsic directions { $\hat{e}_t$, $\hat{e}_n$, $\hat{e}_b$ } for a point P moving with velocity $\underline{v}$ on a curve C relative to a reference frame { $\hat{i}$, $\hat{j}$, $\hat{k}$ } are defined by

$\hat{e}_t$ = _____; $\hat{e}_n$ = _____; and $\hat{e}_b$ = _____

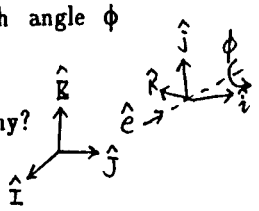


(C) (3%)Referring to (B), the acceleration of P relative to { $\hat{i}$, $\hat{j}$, $\hat{k}$ } in components along { $\hat{e}_t$, $\hat{e}_n$, $\hat{e}_b$ } is

$\underline{a}$ = _____

(D) (3%)What is the definition of a conservative force field? Physically what does this definition mean?

(E) (3%)Suppose a reference frame { $\hat{i}$, $\hat{j}$, $\hat{k}$ } is rotated through angle ϕ about an axis $\hat{e}$ fixed in another reference frame {$\hat{I}$, $\hat{J}$, $\hat{K}$}. Can such a finite rotation be represented by a vector $\phi\hat{e}$? Why?



(F) (5%)What is the meaning of virtural displacement? Are there any

restrictions imposed on it? What is the definition of virtual work? and describe the principle of virtual work

PART II.

(G) (30%)The circular disk of mass M and radius R is mounted on the vertical shaft with an angle α between its plane and the plane of rotation of the shaft.

(i) Determine an expression for the anglar momentum H of the disk about O,

(ii) Find the angle β which the angular momentum H makes with the shaft if $\alpha = 10^{\circ}$,

(iii) Determine the bending moment M acting on the shaft due to the wobble of the disk at a shaft speed of ω rad/sec.

(H) (20%)A simple beam of length L is hinged at one end and the other end is dropped from rest through a height H as shown in next page. If the beam truns as a rigid body until impact, and if there is no loss of energy and no rebound at supports, find the resulting free vibration.

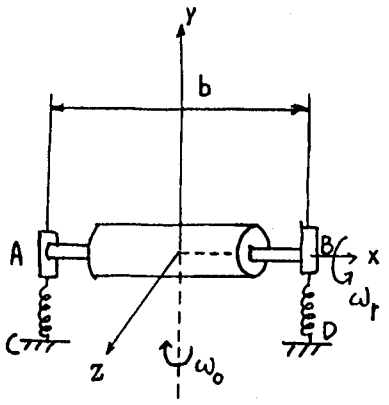
(I) (15%)A slender rod is shaped into the semicircle of radius r as shown in next page. Determine (i) the differential equation of motion and (ii) the natural frequency for small oscillations of the rod when it is pivoted on the horizontal knife edge at the middle of its length.

(J) (15%)The essential structure of a certain type of aircraft turn indicator is shown in the Fig. A rotor spinning at an angular velocity of ω_r rad/s (constant) counterclockwise as viewed from the right is supported on two springs AC and BD, a distance b apart. The plane executes a horizontal turn at angular velocity ω_0 (constant) clockwise as viewed from the top. The coordinate system xyz rotates with the plane.

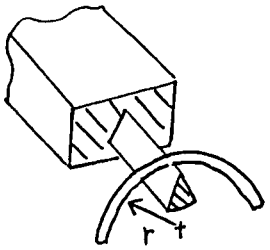
(i) Obatin the modified Euler equations,

(ii)determine the change in length of each spring from the equilibrium position. Let K_s be the spring constant of each spring.

prob (J)



prob (I)



Prob (G)

prob (H)