APL100 MECHANICS MINOR II

26th March 2018

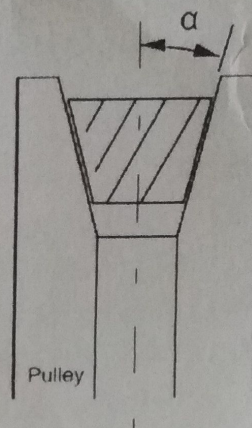
60 MARKS

11:00 am - 12:00 pm

5 marks will be deducted if you have not filled your name, entry no., and group no. in the answer script

Q-1(a). Consider a "Vee" belt on a pulley as shown in the figure. The belt is slipping on the pulley and the coefficient of kinematic friction between the belt and the pulley is μ_k. The half angle of the "Vee" is α. Show that the results for a flat belt are applicable here with μ_k replaced by:

$$\mu_{eff} = \mu_k / \sin\alpha$$



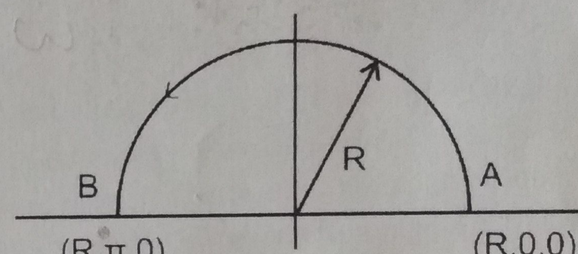
Note: In a "Vee" belt the contact with the pulley is only on the sides not at the bottom.

(6)

Q-1(b). Consider a force field:

$$\vec{F} = (2r\phi + z\phi^2)\hat{e}_r + (r + 2z\phi)\hat{e}_\phi + \phi^2 r\hat{e}_z.$$

What is the work done by the force $\vec{F}$ when the point of application of this force moves from A(R,0,0) to B(R,π,0) along the semicircular path shown.



(9)

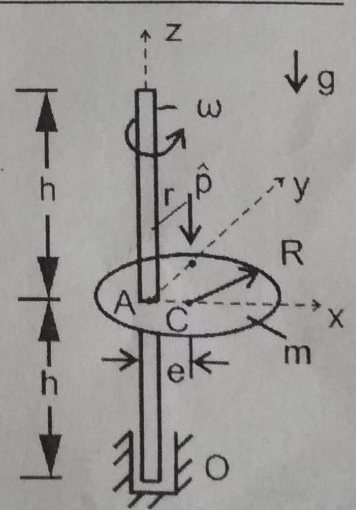
Q-2(a). Starting from : $T_{/I} = \frac{1}{2} m V_{c/I}^2 + \frac{1}{2}\int V_{pc/I}^2 \, dm$

Show that:

$$\dot{T}_{/I} = \vec{F}_R \cdot \vec{V}_{C/I} + \vec{M}_C \cdot \vec{\omega}_{/I}$$

(6)

Q-2(b). A disc of mass m is eccentrically mounted on a **light** vertical rod at A as shown. The rod is supported on a long bearing at O which permits free rotation about the Z-axis. The Centre of mass of the disc is C and its radius is R. The initial angular speed of the rod is ω. An impulsive force $\hat{p}$ strikes the disc at location $r\hat{j}$ as shown (r < R).



Determine:

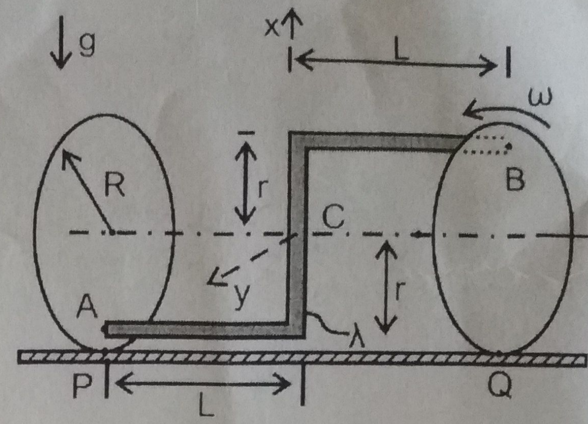
i) The angular speed ω' of the rod immediately after the impulse.

ii) The impulsive force- couple (moment) reaction at O.

(9)

rigidly

Q-3. Two **light** circular discs of radius R are connected by a bent rod ACB as shown. The mass per unit length of the rod is λ. The discs are rolling on the ground at a constant rate ω and there is no slip at the contacts with the ground (P and Q). You may assume that the friction forces at P and Q are only along y direction.



i) Determine $\vec{a}_C$.

ii) Show that the friction forces at P and Q are zero.

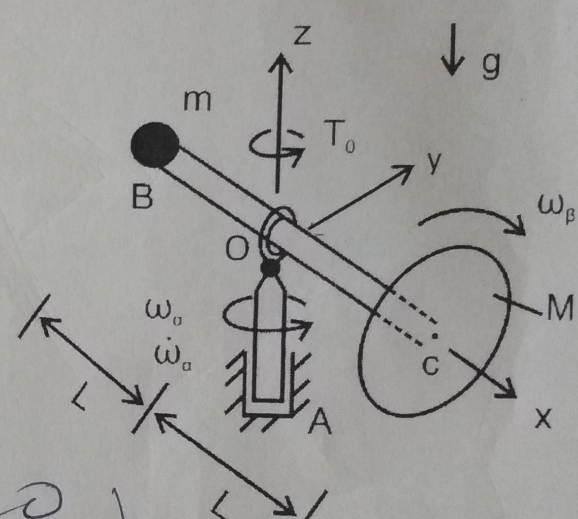
iii) Determine the normal reactions at P and Q.

iv) Determine the angular speed ω^* at which one of the normal reactions becomes zero in the position shown.

(15)

ω.

Q-4. A **light** hollow shaft BC is attached to a disc of mass M and radius R at one end and a point mass 'm' at the other end. The shaft is supported by a thin bearing at O connected to a **light** vertical rod AO. The bearing allows the shaft to rotate about the x and y axes shown. However the rotation of rod OA about the z axis is transmitted to the shaft BC by the bearing. Rod OA rotates at the rates ω_α and $\dot{\omega}_\alpha$ as shown while the shaft BC rotates about its axis at ω_β in the direction shown.



constant ($\dot{\omega}_\beta = 0$)

Determine:

i) The torque T_0.

ii) The mass 'm' needed to maintain the shaft BC horizontal i.e. no tendency to rotate about the 'y' direction.

(15)

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