國立成功大學

113學年度碩士班招生考試試題

編　號：132

系　所：航空太空工程學系

科　目：動力學

日　期：0201

節　次：第 2 節

備　註：不可使用計算機

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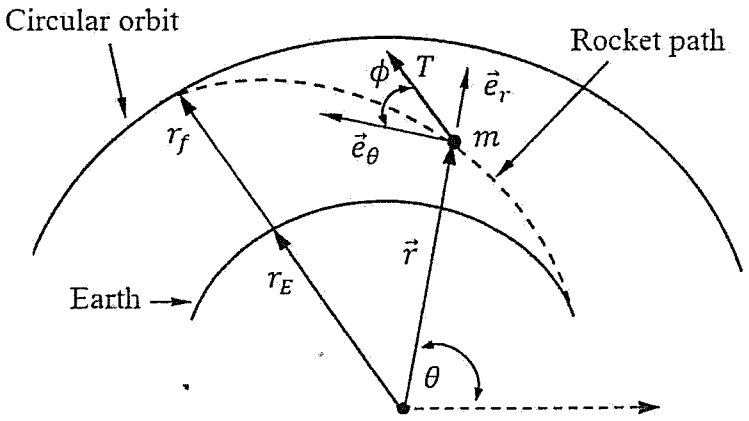
1. (25%) This problem considers the motion of a rocket launched from the earth's surface to a circular orbit in space. Assume that the rocket is a particle with mass m, and its position is represented by polar coordinates (r, θ) with position vector $\vec{r} = r\vec{e}_r$, as shown in the figure below.

   (a) (10%) Let the rocket's velocity be expressed by $\vec{v} = \dot{\vec{r}} = v_r\vec{e}_r + v_\theta\vec{e}_\theta$. Find the velocity components v_r and v_θ in terms of $(r, \theta, \dot{r}, \dot{\theta})$.

   (b) (15%) Let the rocket's acceleration be expressed by $\vec{a} = \ddot{\vec{r}} = a_r\vec{e}_r + a_\theta\vec{e}_\theta$. Find the acceleration components a_r and a_θ in terms of $(r, \theta, \dot{r}, \dot{\theta}, \ddot{r}, \ddot{\theta})$.



2. (25%) Continue the discussion on the previous question. Assume that the rocket is subject to two forces during its motion: gravity $\vec{F}_g$ and thrust $\vec{F}_T$. The radius of the Earth is r_E, and the gravitational acceleration on the earth surface is g_0. The thrust magnitude T of the rocket is fixed, and there is an angle ϕ between the thrust direction and $\vec{e}_\theta$, as shown in the figure above. The initial mass of the rocket is m_0, and the combustion rate of the fuel is $\dot{m}$ (kg/sec), so the mass of the rocket $m = m_0 - \dot{m}t$ is a function of time.

   (a) (5%) Find the gravity vector $\vec{F}_g$ at the distance r.

   (b) (5%) Assume that the radius of the circular orbit that the rocket will enter is r_f. Find the velocity vector $\vec{v}_f$ required for the rocket to enter the orbit and express it with r_f.

   (c) (15%) Apply the Newton second law $m\ddot{\vec{r}} = \vec{F}_g + \vec{F}_T$ to derive the equations of motion of the rocket in the $\vec{e}_r$ and $\vec{e}_\theta$ directions, respectively.

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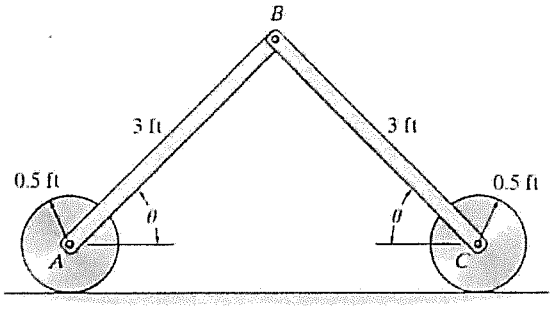
3. (20%) The assembly consists of two 10-lb bars which are pin connected to the two 12-lb disks. Assume the disks roll without slipping.

(a) If the bars are released from rest when $\theta = 60°$, determine the velocities of bars and disks at the instant $\theta = 0°$.

(b) If the bars are released from rest when $\theta = 60°$, determine the velocities of bars and disks at the instant $\theta = 30°$.



4. (30%) (a) The jet aircraft is propelled by four engines to increase its speed uniformly from rest to 300 km/h in a distance of 2000 m. Determine the thrust **T** developed by each engine and the normal reaction on the nose wheel *A*. The aircraft's total mass is 160 Mg and the mass center is at point G. Neglect air and rolling resistance and the effect of lift.

(b) The same aircraft with a landing speed of 200 km/h reduces its speed to 60 km/h with a negative thrust **R** developed by each engine from its jet thrust reversers in a distance of 500 m along the runway with constant deceleration. Determine the reversed trust **R** and the normal reaction on the nose wheel *A* toward the end of the braking interval and prior to the application of mechanical braking. Neglect air and rolling resistance and the effect of lift.