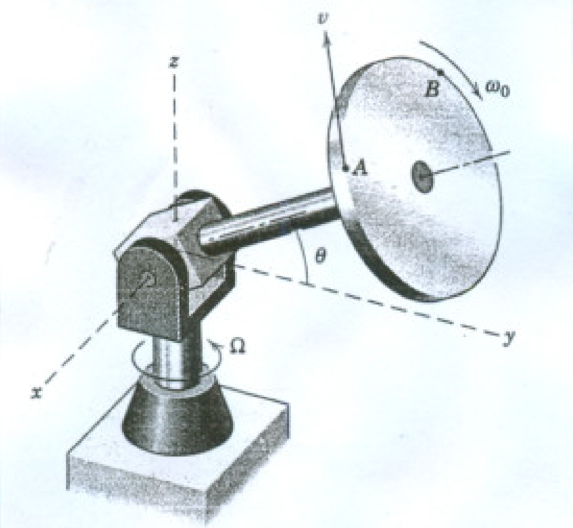
AE- 231
ELEMENTS OF VIBRATION.

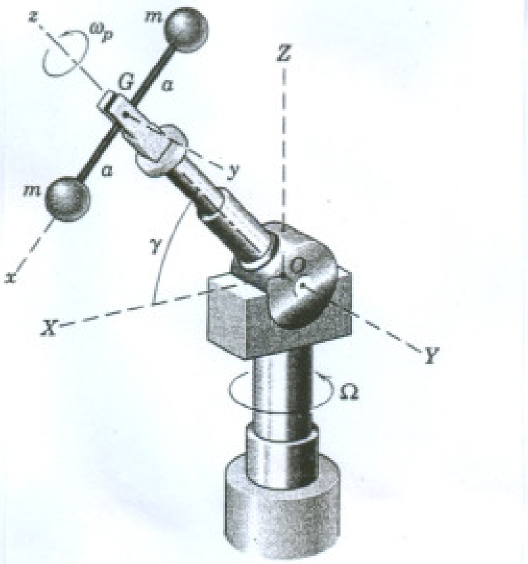
(1) The rotor and shaft are mounted in a clevis which can rotate about the z-axis with an angular velocity Ω. With $\Omega = 0$ and θ constant, the rotor has an angular velocity $\boldsymbol{\omega}_0 = -4\mathbf{j} - 3\mathbf{k}$ rad/s. Find the velocity $\mathbf{v}_A$ of point A on the rim if its position vector at this instant is $\mathbf{r} = 0.5\mathbf{i} + 1.2\mathbf{j} + 1.1\mathbf{k}$ m. What is the rim speed v_B of any point B?

Ans. $\mathbf{v}_A = -0.8\mathbf{i} - 1.5\mathbf{j} + 2\mathbf{k}$ m/s
$v_B = 2.62$ m/s



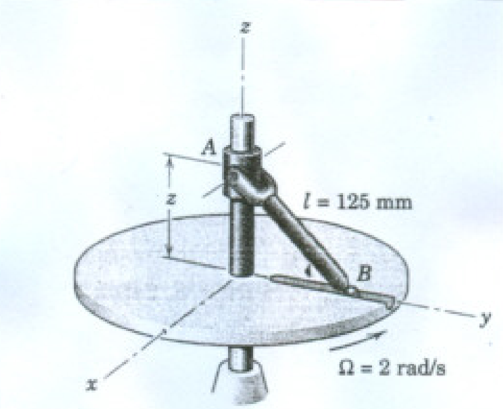
(2) In manipulating the dumbbell, the jaws of the robotic device have an angular velocity $\omega_p = 2$ rad/s about the axis OG with γ fixed at 60°. The entire assembly rotates about the vertical Z-axis at the constant rate $\Omega = 0.8$ rad/s. Determine the angular velocity $\boldsymbol{\omega}$ and angular acceleration $\boldsymbol{\alpha}$ of the dumbbell. Express the results in terms of the given orientation of axes x-y-z, where the y-axis is parallel to the Y-axis.

Ans. $\boldsymbol{\omega} = -0.4\mathbf{i} + 2.69\mathbf{k}$ rad/s
$\boldsymbol{\alpha} = 0.8\mathbf{j}$ rad/s^2



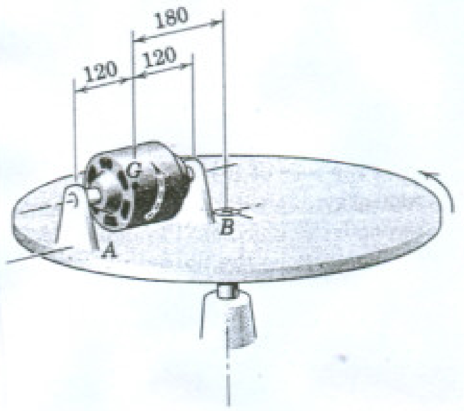
(3) The collar and clevis A are given a constant upward velocity of 0.2 m/s for an interval of motion and cause the ball end of the bar to slide in the radial slot in the rotating disk. Determine the angular acceleration of the bar when the bar passes the position for which $z = 75$ mm. The disk turns at the constant rate of 2 rad/s.

Ans. $\alpha = -3\mathbf{i} - 4\mathbf{j}$ rad/s^2



(4) The electric motor has a total mass of 10 kg and is supported by the mounting brackets A and B attached to the rotating disk. The armature of the motor has a mass of 2.5 kg and a radius of gyration of 35 mm and turns counterclockwise at a speed of 1725 rev/min as viewed from A to B. The turntable revolves about its vertical axis at the constant rate of 48 rev/min in the direction shown. Determine the vertical components of the forces supported by the mounting brackets at A and B.

Ans. $R_A = 37.5$ N, $R_B = 60.6$ N

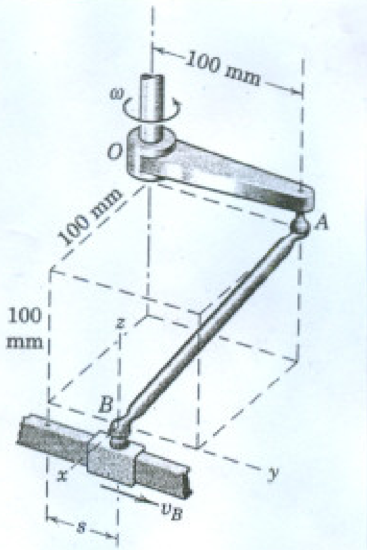


Dimensions in millimeters

(5)

Link AB is secured to the rotating arm OA and to the slider at B by a ball-and-socket joint at each end. Arm OA is confined to rotate about the fixed vertical shaft, and the slider is confined to move along the fixed rectangular bar. If the velocity of the slider is $v_B = 0.5$ m/s when $s = 50$ mm with OA in the position shown, calculate the corresponding angular velocity $\boldsymbol{\omega}_n$ of link AB. Use the nonrotating axes x-y-z attached to B.

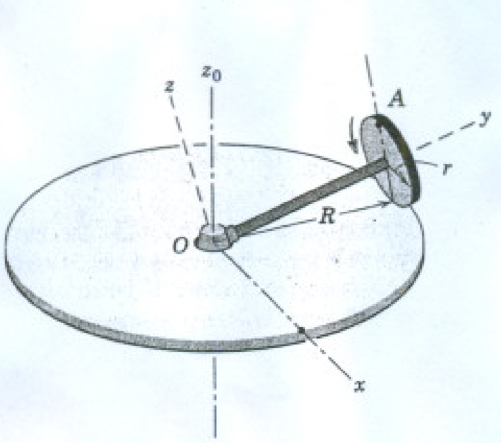
Ans. $\boldsymbol{\omega}_n = \frac{5}{9}(4\mathbf{i} - 2\mathbf{j} + 5\mathbf{k})$ rad/s



(6)

The circular disk of radius r is mounted on its shaft which is pivoted at O so that it may rotate about the vertical z_0-axis. If the disk rolls at constant speed without slipping and makes one complete turn around the circle of radius R in time τ, determine the expression for the absolute angular velocity $\boldsymbol{\omega}$ of the disk. Use axes x-y-z which rotate around the z_0-axis. (*Hint:* The absolute angular velocity of the disk equals the angular velocity of the axes plus (vectorially) the angular velocity relative to the axes as seen by holding x-y-z fixed and rotating the circular disk of radius R at the rate $2\pi/\tau$.)

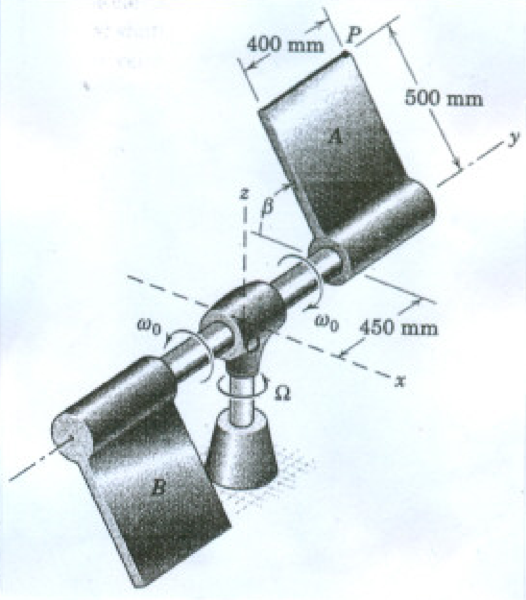
$$\textit{Ans.}\ \boldsymbol{\omega} = \frac{2\pi}{\tau}\left[\left(-\frac{R}{r} + \frac{r}{R}\right)\mathbf{j} + \frac{\sqrt{R^2 - r^2}}{R}\mathbf{k}\right]$$



(7)

The panel assembly and attached x-y-z axes rotate with a constant angular velocity $\Omega = 0.6$ rad/s about the vertical z-axis. Simultaneously, the panels rotate about the y-axis as shown with a constant rate $\omega_0 = 2$ rad/s. Determine the angular acceleration $\boldsymbol{\alpha}$ of panel A and find the acceleration of point P for the instant when $\beta = 90°$.

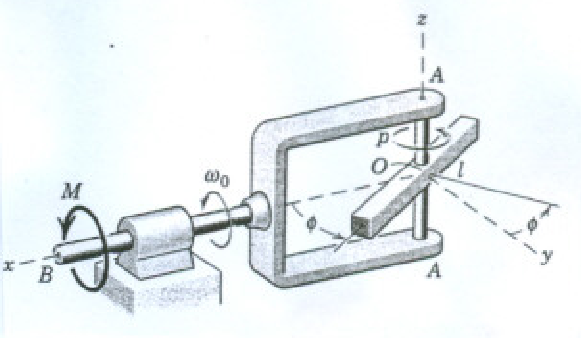
Ans. $\boldsymbol{\alpha} = -1.2\mathbf{i}$ rad/s^2
$\mathbf{a}_P = 0.894\mathbf{j} - 2\mathbf{k}$ m/s^2



(8)

The uniform slender bar of mass m and length l is centrally mounted on the shaft A-A, about which it rotates with a constant speed $\dot{\phi} = p$. Simultaneously, the yoke is forced to rotate about the x-axis with a constant speed ω_0. As a function of ϕ, determine the magnitude of the torque M required to maintain the constant speed ω_0. (*Hint:* Apply Eq. 7/19 to obtain the x-component of M.)

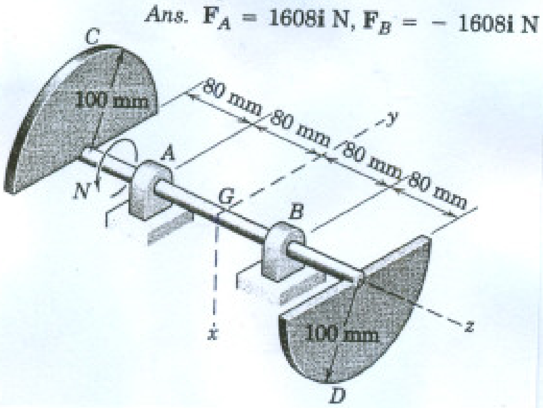
Ans. $M = \frac{1}{12} ml^2 p\omega_0 \sin 2\phi$



(9)

Each of the two semicircular disks has a mass of 1.20 kg and is welded to the shaft supported in bearings A and B as shown. Calculate the forces applied to the shaft by the bearings for a constant angular speed $N = 1200$ rev/min. Neglect the forces of static equilibrium.

Ans. $\mathbf{F}_A = 1608\mathbf{i}$ N, $\mathbf{F}_B = -1608\mathbf{i}$ N



(10)

For the rotating square plate of Prob. 7/32, determine the velocity and acceleration of the corner A for the position where $\phi = 0$ and $\theta = 30°$ if $\dot{\phi} \neq 0$ and $\ddot{\theta} = 0$. The distance $\overline{OB}$ is R.

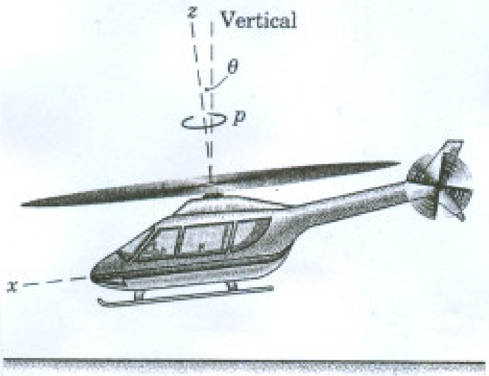
$$\textit{Ans.}\ \mathbf{v}_A = \left(\frac{b}{\sqrt{2}}\dot{\phi} - R\dot{\theta}\right)\mathbf{j}$$

$$\mathbf{a}_A = (-R\dot{\theta} + b\sqrt{2}\dot{\phi})\dot{\theta}\mathbf{k} - \frac{b}{\sqrt{2}}\dot{\phi}^2\mathbf{i}$$

(11)

The blades and hub of the helicopter rotor have a mass of 64 kg and have a radius of gyration of 3 m about the z-axis of rotation. With the rotor turning at 500 rev/min during a short interval following vertical liftoff, the helicopter tilts forward at the rate $\dot{\theta} = 10$ deg/s in order to acquire forward velocity. Determine the gyroscopic moment M transmitted to the body of the helicopter by its rotor and indicate whether the helicopter tends to deflect clockwise or counterclockwise, as viewed by a passenger facing forward.

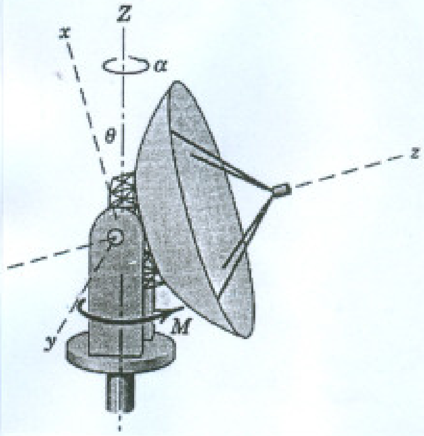
Ans. $M = 5.26$ kN·m



(12)

The large satellite-tracking antenna has a moment of inertia I about its z-axis of symmetry and a moment of inertia I_O about each of the x- and y-axes. Determine the angular acceleration α of the antenna about the vertical Z-axis caused by a torque M applied about Z by the drive mechanism for a given orientation θ.

$$\textit{Ans.}\ \alpha = \frac{M}{I_O \cos^2\theta + I \sin^2\theta}$$



(13)

The circular disk of mass m and radius r is mounted on the vertical shaft with a small angle α between its plane and the plane of rotation of the shaft. Determine the expression for the bending moment $\mathbf{M}$ acting *on* the shaft due to the wobble of the disk at a shaft speed of ω rad/s.

Ans. $\mathbf{M} = (\frac{1}{8}mr^2\omega^2 \sin 2\alpha)\,\mathbf{j}$