Palestine Technical University- Kadoorie (PTUK)

Mechanical Engineering Department

12210244: Dynamics

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This is an explanation of the Dynamics course

offered at Palestine Technical University - Kadoorie

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Textbook:

Engineering Mechanics: Dynamics, 7th Edition

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Chapter Six: Plane Kinetics of Rigid Bodies

Section Six: Work-Energy Relations

6.6 Work-Energy Relations

- Work

$$U_{1\to 2} = \int_1^2 \vec{F} \cdot d\vec{r}$$

$$U_{1\to 2} = \int_{\theta_1}^{\theta_2} M \, d\theta$$

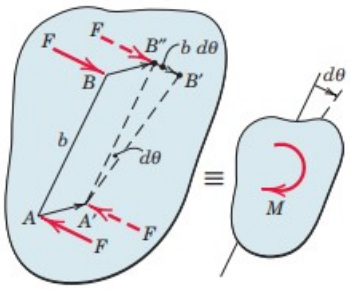


Figure 6/11

- Kinetic Energy
  - Translation

$$T = \frac{1}{2}mv^2$$

  - Fixed-axis rotation

$$T = \frac{1}{2}I_O\omega^2$$

  - General plane motion

$$T = \frac{1}{2}mv_G^2 + \frac{1}{2}I_G\omega^2 = \frac{1}{2}I_C\omega^2$$

- Potential Energy and the Work-Energy Equation

$$T_1 + U_{1\to 2} = T_2$$

$$T_1 + V_1 + U'_{1\to 2} = T_2 + V_2$$

- Power

$$P = \vec{F} \cdot \vec{v}$$

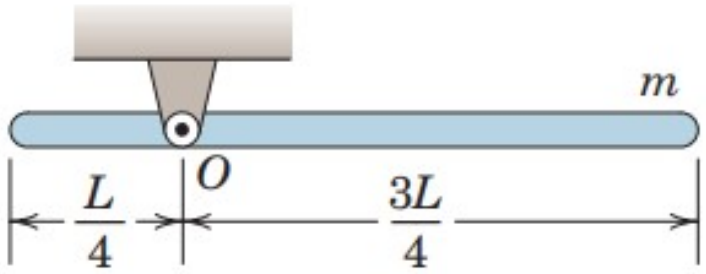
$$P = M\omega$$

End of Section 6.6

Example 1:

The uniform slender bar of mass $m = 5\ kg$ and length $L = 4\ m$ is released from rest when in the horizontal position shown. Determine its angular velocity and mass center speed as it passes the vertical position

ans. $\omega = 2.9\ rad/sec\ CW$ $v_G = 2.9\ m/sec$

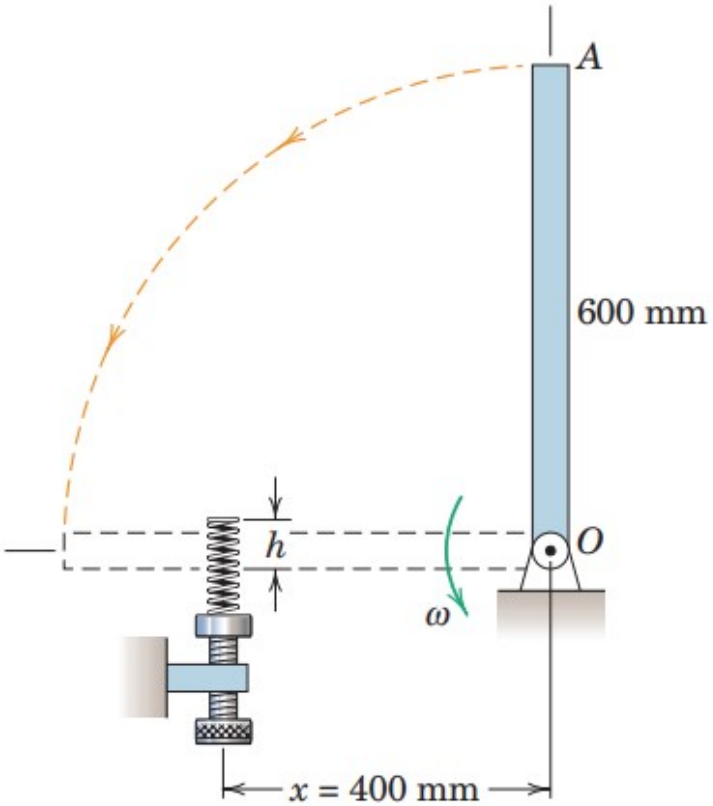


Ans.

Example 2:

The 15 kg slender bar OA is released from rest in the vertical position and compresses the spring of stiffness $k = 20\ KN/m$ as the horizontal position is passed. Determine the proper setting of the spring, by specifying the distance h, which will result in the bar having an angular velocity as it crosses the horizontal position.

ans. $h = 54.5\ mm$

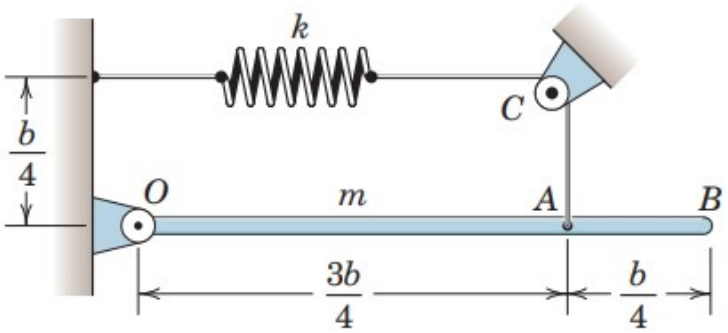


Ans.

Example 3:

The uniform slender bar of mass m pivots freely about a horizontal axis through O. If the bar is released from rest in the horizontal position shown where the spring is unstretched, it is observed to rotate a maximum of 30° clockwise. The spring constant $k = 200\ M/m$ and the distance $b = 200\ mm$ Determine: (a) the mass m of the bar and (b) the angular velocity of the bar when the angular displacement is 15° clockwise from the release position

ans. $m = 1.196\ kg$ $\omega = 4.36\ rad/sec\ CW$



Ans.

Chapter Six: Plane Kinetics of Rigid Bodies

Section Seven: Impulse-Momentum Equations

6.7 Impulse-Momentum Equations

- Linear Momentum

$$\vec{G} = m\vec{v}_G$$

$$\sum \vec{F} = \dot{\vec{G}}$$

$$\sum F_x = \dot{G}_x \qquad \sum F_y = \dot{G}_y$$

$$\vec{G}_1 + \int_{t_1}^{t_2} \sum \vec{F}\, dt = \vec{G}_2$$

$$(G_x)_1 + \int_{t_1}^{t_2} \sum \vec{F}_x\, dt = (G_x)_2$$

$$(G_y)_1 + \int_{t_1}^{t_2} \sum \vec{F}_y\, dt = (G_y)_2$$

- Angular Momentum

$$H_G = I_G\omega$$

$$\sum \vec{M}_G = \dot{\vec{H}}_G$$

$$(H_G)_1 + \int_{t_1}^{t_2} \sum M_G\, dt = (H_G)_2$$

$$H_O = I_G\omega + mv_G d$$

$$H_O = I_O\omega$$

$$\sum \vec{M}_O = \dot{\vec{H}}_O$$

$$(H_O)_1 + \int_{t_1}^{t_2} \sum M_O\, dt = (H_O)_2$$

- Conservation of Momentum

$$G_1 = G_2$$

$$(H_G)_1 = (H_G)_2$$

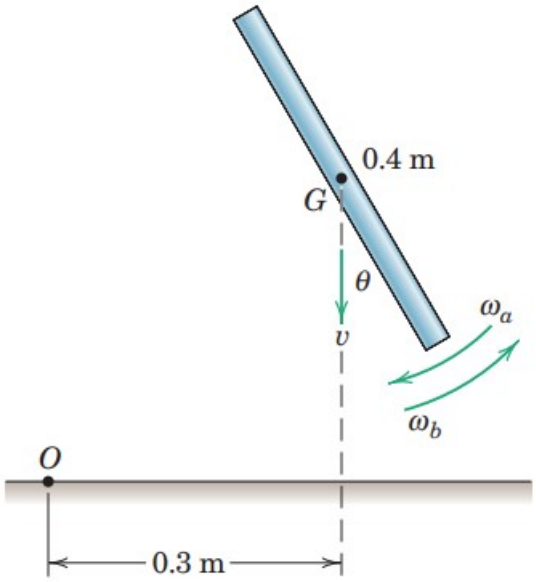
$$(H_O)_1 = (H_O)_2$$

End of Section 6.7

Example 1:

The mass center G of the slender bar of mass 0.8 kg and length 0.4 m is falling vertically with a velocity $v = 2\ m/sec$ at the instant depicted. Calculate the angular momentum of the bar about point O if the angular velocity of the bar is (a) $\omega_a = 10\ rad/sec$ clockwise and (b) $\omega_a = 10\ rad/sec$ counterclockwise

ans. $a) H_O = 0.487\ Kg.m^2/sec$ $b) H_O = 0.373\ Kg.m^2/sec$

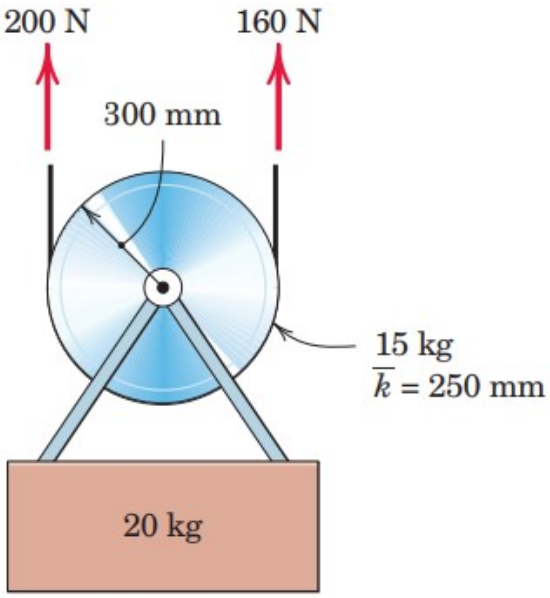


Ans.

Example 2:

The constant tensions of 200 N and 160 N are applied to the hoisting cable as shown. If the velocity v of the load is 2 m/s down and the angular velocity ω of the pulley is 8 rad/s counterclockwise at time $t = 0$ sec determine v and ω after the cable tensions have been applied for 5 s. Note the independence of the results

ans. $v = 0.379\ m/sec\ Up$ $\omega = 46\ rad/sec\ CW$

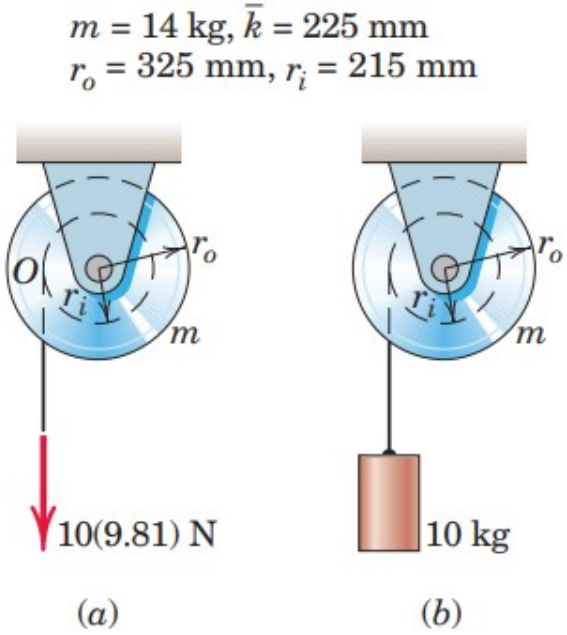


Ans.

Example 3:

The grooved drums in the two systems shown are identical. In both cases, (a) and (b), the system is at rest at time $t = 0$ sec. Determine the angular velocity of each grooved drum at time $t = 4$ sec Neglect friction at the pivot O.

ans. *a)* $\omega = 119\ rad/sec\ CCW$ *b)* $\omega = 72\ rad/sec\ CCW$



Ans.