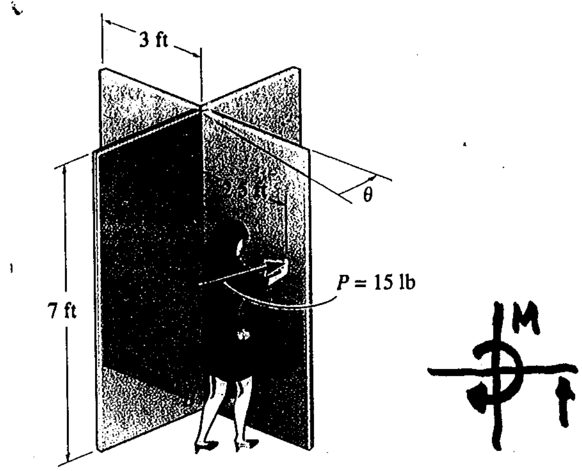
EGN 3321

Dynamics

4/13/05

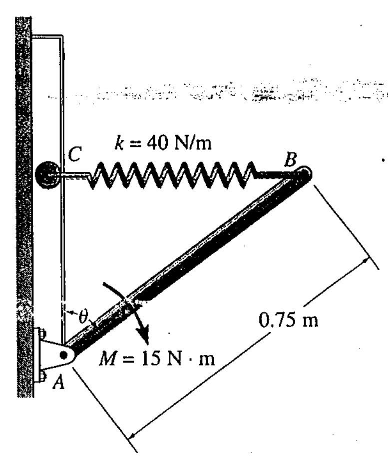
18–9 The revolving door consists of four doors which are attached to an axle AB. Each door can be assumed to be a 50-lb thin plate. Friction at the axle contributes a moment of 2 lb · ft which resists the rotation of the doors. If a woman passes through one door by always pushing with a force $P = 15$ lb perpendicular to the plane of the door as shown, determine the door's angular velocity after it has rotated 90°. The doors are originally at rest.



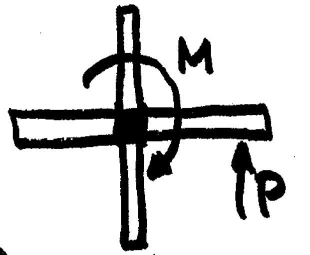
Prob. 18–9

100-lb
ıe con-
disk is
ɔns the
Vhat is

18–15 The 10-kg rod AB is pin-connected at A and subjected to a couple moment of $M = 15$ N · m. If the rod is released from rest when the spring is unstretched, at $\theta = 30°$, determine the rod's angular velocity at the instant $\theta = 60°$. As the rod rotates, the spring always remains horizontal, because of the roller support at C.



Prob. 18–15



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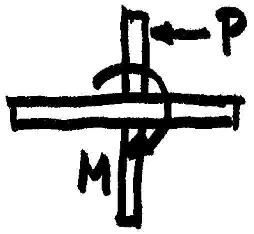

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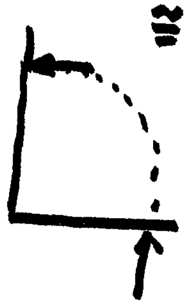
$$T_1 = 4\left[\tfrac{1}{2} I_A \omega_1^2\right] = 0 \quad \text{since } \omega_1 = 0$$

$$T_2 = 4\left[\tfrac{1}{2} I_A \omega_2^2\right] \qquad I_A = \tfrac{1}{3} m l^2$$

$$\Sigma U_{1-2} = P \cdot \Delta s - M \Delta\theta \qquad = \tfrac{1}{3}\,\tfrac{50}{32.2}(3)^2 \sim 4.95$$

$$= 15(2) - 2(.758)$$

$$\cong 28.5$$

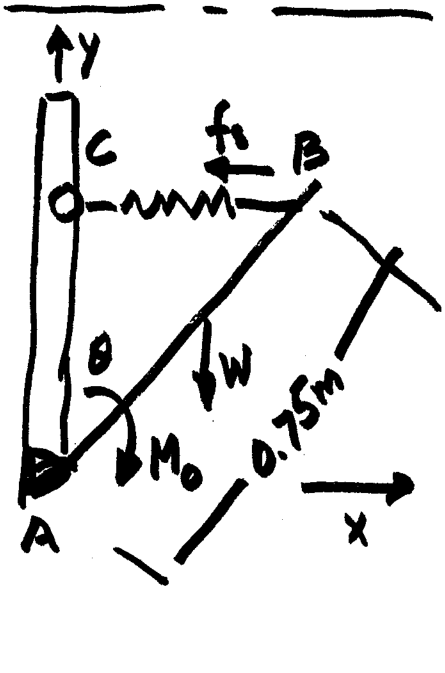


$$\Delta s = 2.5 \cdot \Delta\theta = 2.5 \cdot \frac{\pi}{4} \sim 2$$

$$\Delta\theta = \pi/4 = .758$$

$$T_A = \tfrac{1}{2} m \cancel{v_A^2} + \tfrac{1}{2} m\omega\left[\cancel{\bar{x} v_{Ax}} \cancel{+ \bar{y} v_{Ay}}\right] + \tfrac{1}{2} I_A \omega^2$$

$\omega \sim 1.7$ rad/s



when $\theta = 30°$ $f_s = 0$

find ω when $\theta = 60°$

when $\theta = 30°$ then $CD = 0.75 \sin 30°$
$= 0.375$

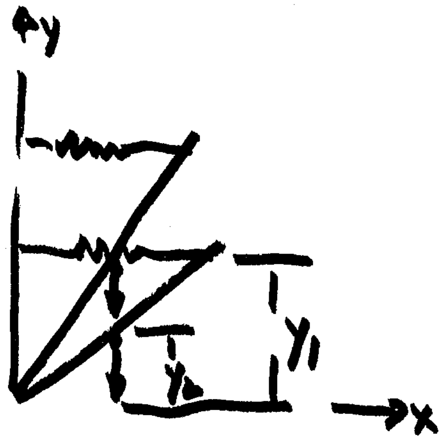
this is original length of spring

when $\theta = 60°$ then $CD = 0.75 \sin 60°$
$= 0.75(.866)$

$$U_{1-2} = -W\Delta y$$

$$= -10(9.81)\,\Delta y$$

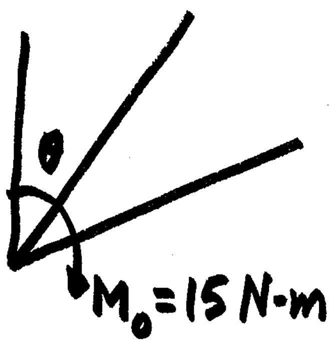
$$U_{1-2} = -\tfrac{1}{2} k (s_2^2 - s_1^2) = -\tfrac{1}{2} k \Delta s^2 = -\tfrac{1}{2} k \left[0.75(.866) - 0.375\right]^2$$



$y_1 = 0.375\cos 30^\circ$

$y_2 = 0.375\cos 60^\circ$

$U_{1-2} = -W\Delta y = -10(9.81)(0.375)[\cos 60 - \cos 3$



$$U_{1-2} = M\Delta\theta$$

$$= 15(60^\circ - 30^\circ)\cdot\frac{\pi}{180}$$

$$\Sigma U_{1-2} = -98.1(0.375)(0.5 - 0.866)$$

$$+ 15\left(\frac{\pi}{3} - \frac{\pi}{6}\right) - \frac{1}{2}k\left[0.75(.866) - 0.375\right]^2$$

$$T_1 = \frac{1}{2}mV_G^2 + \frac{1}{2}I_G\omega^2 = \frac{1}{2}I_A\omega^2 = \frac{1}{2}\left(\frac{1}{3}m\ell^2\right)\omega^2 \quad \omega = 0$$

$$T_2 = \frac{1}{2}\left(\frac{1}{3}m\ell^2\right)\omega_2^2 = \frac{1}{6}\,10(0.75)^2\omega_2^2$$

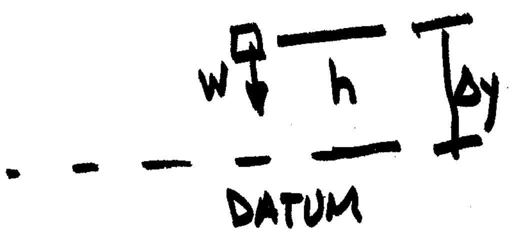
$\omega = 4.597$ rad/s $\qquad T_1 + \Sigma U_{1-2} = T_2$

CONSERVATION OF ENERGY

FOR A RIGID BODY TO WHICH ARE APPLIED CONSERVATIVE FORCES, YOU CAN USE CONSERVATION OF ENERGY PRINCIPLES

- WORK OF A CONSERVATIVE FORCE IS INDEPENDENT OF PATH, BUT DEPENDS ON END POINTS.

GRAVITATIONAL POTENTIAL ENERGY



$$V_g = Wh = W\Delta y$$

h - is measured to the Center of Mass

ELASTIC POTENTIAL ENERGY

$$V_e = \frac{1}{2}k\Delta s^2$$

$\sum U_{1-2}$ - work done by external forces

$$= \left(\sum U_{1-2}\right)_{cons.} + \left(\sum U_{1-2}\right)_{non-conserv.}$$

$$= V_1 - V_2 + \left(\sum U_{1-2}\right)_{n.c.}$$

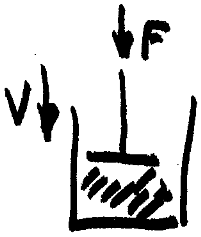
$$T_1 + \sum U_{1-2} = T_2$$

$$T_1 + V_1 + \left(\sum U_{1-2}\right)_{n.c.} = T_2 + V_2$$

what happens when $\left(\sum U_{1-2}\right)_{n.c.} = 0$

$\Longrightarrow T_1 + V_1 = T_2 + V_2$ $\qquad$ $T + V = \text{constant.}$

Conservation of Energy Principle



$F = cV$

$F_{n.c.}$

We can use this principle for problems that involve velocity, displacement & conservative forces.

Prob. 18-49 in 10th ed P.467

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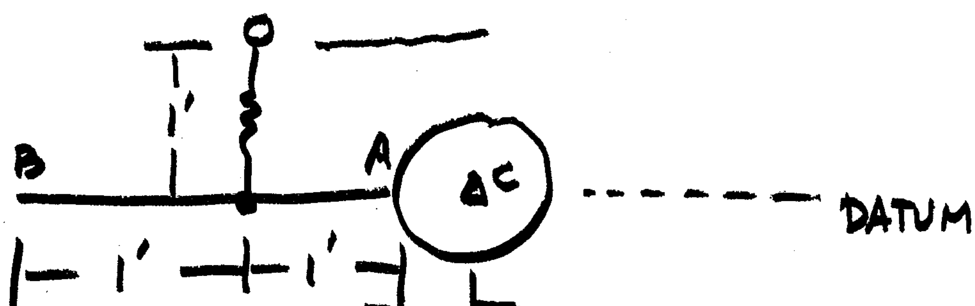
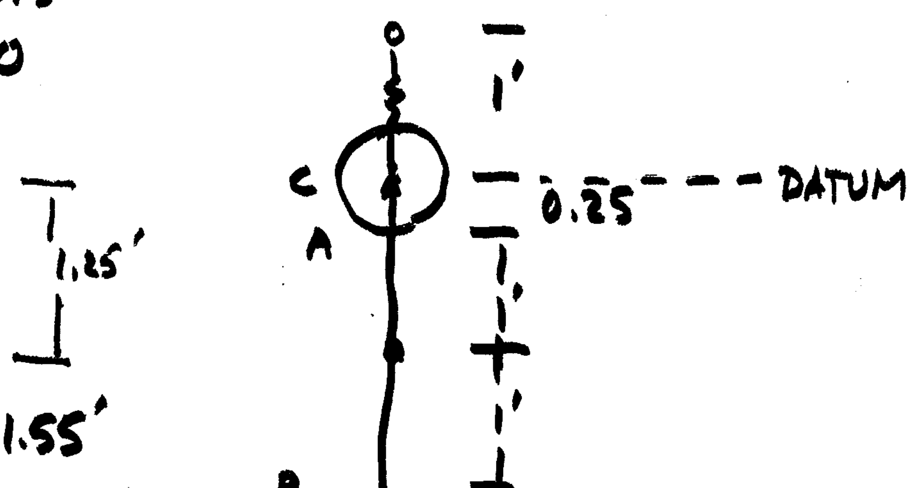


$(s_1)_{spring} = 0.3$

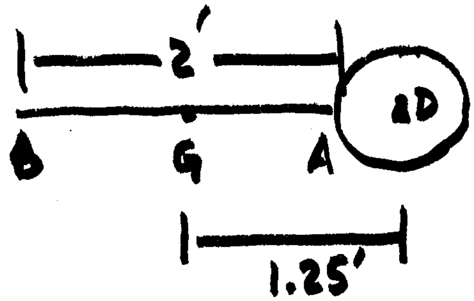
$(Y_1)_{mass} = 0$

②



$(s_2)_{spring} = 1.55'$

$(Y_2)_{mass} = -1.25'$



$$I_D^{rod} = I_G^{rod} + m\,d_{G/D}^2$$
$$= \frac{1}{12} m_{rod} \ell_{rod}^2 + m_{rod} \cdot d_{G/D}^2$$
$$= \frac{1}{12}\left(\frac{2}{32.2}\right) \cdot 2^2 + \left(\frac{2}{32.2}\right)(1.25')^2$$
$$= 0.118 \text{ slug} \cdot \text{ft}^2 = 0.118 \text{ ft-lb-s}^2$$
$$\frac{\text{lb}}{\text{ft/s}^2}$$

$$I_D^{disk} = \frac{1}{2} m_{disk} \cdot r_{disk}^2 = \frac{1}{2}\left(\frac{6}{32.2}\right)(0.25)^2$$
$$= 0.00582 \text{ slug-ft}^2 \,(\text{ft-lb-s}^2)$$

$$T_1 = \frac{1}{2} I_{D_{TOT}} \cancel{\omega_1^2}^{\,0}$$
$$T_2 = \frac{1}{2}(0.124)\,\omega_2^2$$

$$T_1 + V_1 = T_2 + V_2$$
$$0 + \frac{1}{2} k s_1^2 = \frac{1}{2}(0.124)\omega_2^2 + \frac{1}{2} k s_2^2 - W(1.25)$$
$$\frac{1}{2}(2)(0.3)^2 = \frac{1}{2}(0.124)\,\omega_2^2 + \frac{1}{2}(2)(1.55')^2 - 2(1.25)$$

$$\omega = 1.74 \text{ rad/s}$$

HW Due 4/20 18-13, 25, 44

Total ~~internal~~ initial translational & rotational KE + work done by external forces & moments = total final translational + Rotational KE.

$$T_1 = \left(\sum \tfrac{1}{2} m_i \underline{v}_{G_i}^2 + \sum \tfrac{1}{2} I_{G_i}\omega_i^2\right)_1$$

$$T_2 = \left(\sum \tfrac{1}{2} m_i \underline{v}_{G_i}^2 + \sum \tfrac{1}{2} I_{G_i}\omega_i^2\right)_2$$

$$\sum U_{1-2} = \sum \int \left(\underline{F}_{external} \cdot \underline{dr}\right)_i$$