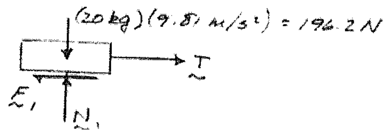
Chapter 8, Solution 11.

FBD top block:



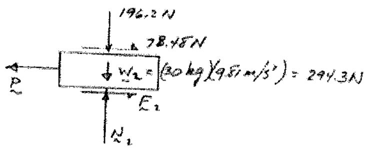
$\uparrow \Sigma F_y = 0$: $\quad N_1 - 196.2 \text{ N} = 0$

$$\mathbf{N}_1 = 196.2 \text{ N} \uparrow$$

(*a*) With cable in place, impending motion of bottom block requires impending slip between blocks, so $F_1 = \mu_s N_1 = 0.4(196.2 \text{ N})$

$$\mathbf{F}_1 = 78.48 \text{ N} \leftarrow$$

FBD bottom block:



$\uparrow \Sigma F_y = 0$: $\quad N_2 - 196.2 \text{ N} - 294.3 \text{ N} = 0$

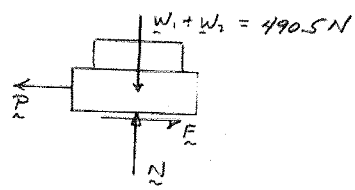
$$\mathbf{N}_2 = 490.5 \text{ N} \uparrow$$

$$F_2 = \mu_s N_2 = 0.4(490.5 \text{ N}) = 196.2 \text{ N}$$

$\rightarrow \Sigma F_x = 0$: $\quad -P + 78.48 \text{ N} + 196.2 \text{ N} = 0$

P = 275 N $\leftarrow$ ◀

FBD block:



(*b*) Without cable *AB*, top and bottom blocks will move together

$\uparrow \Sigma F_y = 0$: $\quad N - 490.5 \text{ N} = 0, \qquad N = 490.5 \text{ N}$

Impending slip: $\quad F = \mu_s N = 0.40(490.5 \text{ N}) = 196.2 \text{ N}$

$\rightarrow \Sigma F_x = 0$: $\quad -P + 196.2 \text{ N} = 0$

P = 196.2 N $\leftarrow$ ◀

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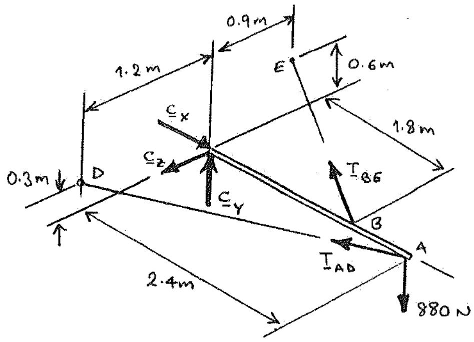
Chapter 4, Solution 116.

Free-Body Diagram:



Express all forces in terms of rectangular components:

$$\mathbf{r}_A = (2.4\text{ m})\mathbf{i}$$

$$\mathbf{r}_B = (1.8\text{ m})\mathbf{j}$$

$$\overrightarrow{AD} = -(2.4\text{ m})\mathbf{i} + (0.3\text{ m})\mathbf{j} + (1.2\text{ m})\mathbf{k}$$

$$\overrightarrow{BE} = -(1.8\text{ m})\mathbf{i} + (0.6\text{ m})\mathbf{j} - (0.9\text{ m})\mathbf{k}$$

$$\mathbf{W} = -(880\text{ N})\mathbf{j}$$

Then

$$\vec{T}_{AD} = T_{AD}\frac{\overrightarrow{AD}}{AD} = T_{AD}\frac{-2.4\mathbf{i} + 0.3\mathbf{j} + 1.2\mathbf{k}}{\sqrt{(-2.4)^2 + (0.3)^2 + (1.2)^2}} = -\frac{8}{9}T_{AD}\mathbf{i} + \frac{1}{9}T_{AD}\mathbf{j} + \frac{4}{9}T_{AD}\mathbf{k}$$

$$\vec{T}_{BE} = T_{BE}\frac{\overrightarrow{BE}}{BE} = T_{BE}\frac{-1.8\mathbf{i} + 0.6\mathbf{j} - 0.9\mathbf{k}}{\sqrt{(-1.8)^2 + (0.6)^2 + (-0.9)^2}} = -\frac{6}{7}T_{AD}\mathbf{i} + \frac{2}{7}T_{AD}\mathbf{j} - \frac{3}{7}T_{AD}\mathbf{k}$$

continued

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$\Sigma \mathbf{M}_C = 0$: $\quad \mathbf{r}_A \times \mathbf{T}_{AD} + \mathbf{r}_B \times \mathbf{T}_{BE} + \mathbf{r}_A \times \mathbf{W} = 0$

or

$$\begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 2.4 & 0 & 0 \\ -\frac{8}{9} & \frac{1}{9} & \frac{4}{9} \end{vmatrix} T_{AD} + \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 1.8 & 0 & 0 \\ -\frac{6}{7} & \frac{2}{7} & -\frac{3}{7} \end{vmatrix} T_{BE} + (2.4)\mathbf{i} \times (-880)\mathbf{j} = 0$$

Equating the coefficients of the unit vectors to zero:

$\mathbf{j}$: $\quad -\frac{9.6}{9} T_{AD} + \frac{5.4}{7} T_{BE} = 0$

$\mathbf{k}$: $\quad \frac{2.4}{9} T_{AD} + \frac{3.6}{7} T_{BE} - 2112 = 0$

or $T_{AD} = 2160$ N ◀

$T_{BE} = 2990$ N ◀

Force equations:

$$C_x - \frac{8}{9}(2160.0 \text{ N}) - \frac{6}{7}(2986.7 \text{ N}) = 0, \quad \text{or} \quad C_x = 4480.0 \text{ N}$$

$$C_y + \frac{1}{9}(2160.0 \text{ N}) + \frac{2}{7}(2986.7 \text{ N}) - 880 \text{ N} = 0, \quad \text{or} \quad C_y = -213.34 \text{ N}$$

$$C_z + \frac{4}{9}(2160.0 \text{ N}) - \frac{3}{7}(2986.7 \text{ N}) = 0, \quad \text{or} \quad C_z = 320.01 \text{ N}$$

$\mathbf{C} = (4480 \text{ N})\mathbf{i} - (213 \text{ N})\mathbf{j} + (320 \text{ N})\mathbf{k}$ ◀

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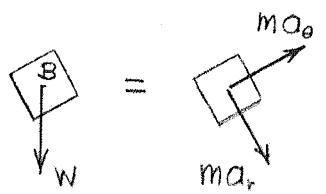
Chapter 12, Solution 66.



$$\theta = 30°, \quad \dot{\theta} = 2 \text{ rad/s}, \quad \ddot{\theta} = 0$$

$$r = 0.6 \text{ m}, \quad W = mg$$

Block B: Only force is weight

$$F_r = W\cos 30°, \quad F_\theta = -W\sin 30°$$

(a) $F_\theta = ma_\theta = m\left(r\ddot{\theta} + 2\dot{r}\dot{\theta}\right)$:

$$2\dot{r}\dot{\theta} = \frac{F_\theta}{m} - r\ddot{\theta} = -\frac{mg\sin 30°}{m} - r\ddot{\theta} = -g\sin 30° - r\ddot{\theta}$$

$$\dot{r} = -\frac{g\sin 30° + r\ddot{\theta}}{2\dot{\theta}} = -\frac{(9.81)\sin 30° + (0.6)(0)}{(2)(2)} = -1.226 \text{ m/s}$$

$\mathbf{v}_{B/\text{rod}} = 1.226$ m/s ⦪ 60° ◀

(b) $F_r = ma_r = m\left(\ddot{r} - r\dot{\theta}^2\right)$:

$$\ddot{r} = r\dot{\theta} + \frac{F_r}{m} = r\dot{\theta}^2 + \frac{mg\cos 30°}{m} = r\dot{\theta}^2 + g\cos 30°$$

$$= (0.6)(2)^2 + (9.81)\cos 30° = 10.90 \text{ m/s}^2$$

$\mathbf{a}_{B/\text{rod}} = 10.90$ m/s² ⦩ 60° ◀

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Chapter 13, Solution 44.

Use work - energy : position 1 is at A, position 2 is at B.

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

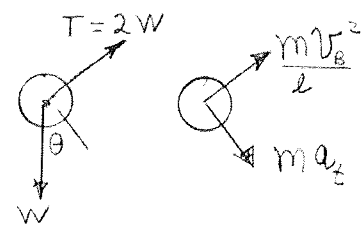
Where $T_1 = 0$; $U_{1\to 2} = mgl\sin\theta$; $T_2 = \frac{1}{2}mv_B^2$

Substitute

$$0 + mgl\sin\theta = \frac{1}{2}mv_B^2$$

$$v_B^2 = 2gl\sin\theta \qquad (2)$$

For $T = 2W$ use Newtons 2nd law.



$$\nearrow \Sigma F_n = ma_n \Rightarrow 2W - W\sin\theta = \frac{mv_B^2}{l} \qquad (3)$$

Substitute (2) into (3)

$$2\cancel{m}g - \cancel{m}g\sin\theta = 2\cancel{m}g\frac{\cancel{l}\sin\theta}{\cancel{l}}$$

$$2 = 3\sin\theta$$

$$\text{or } \sin\theta = \frac{2}{3} \Rightarrow \theta = 41.81°$$

$\theta = 41.8°$ ◀

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Chapter 13, Solution 56.

Use conservation of energy

Let position 1 be where A is compressed 0.1 m; position 2 when B is compressed a maximum distance

So

$$T_1 + V_1 = T_2 + V_2 \qquad (1)$$

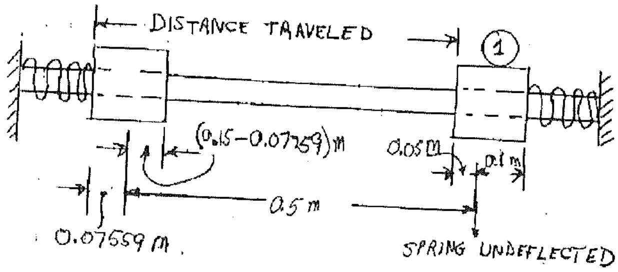
Where

$$T_1 = 0;\ V_1 = \frac{1}{2}k_A x_1^2 = \frac{1}{2}(1600\ \text{N/m})(0.1\ \text{m})^2 = 8\ \text{J}$$

$$T_2 = 0;\ V_2 = \frac{1}{2}k_B x_2^2 = \frac{1}{2}(2800\ \text{N/m})x_2^2 = 1400x_2^2$$

Substituting into (1)

$$0 + 8 = 0 + 1400\, x_2^2 \Rightarrow x_2 = 0.07559\ \text{m}$$



This answer is independent of mass

$$\text{Distance traveled} = 0.5\ \text{m} - 0.05\ \text{m} + 0.07559\ \text{m} = 0.526\ \text{m}$$

The maximum velocity will occur when the mass is between the two springs

where

$$T_1 + V_1 = T_2 + V_2$$

$$T_1 = 0; \qquad V_1 = 8\ \text{J (same as before)}$$

$$T_2 = \frac{1}{2}mv_{\max}^2; \qquad V_2 = 0$$

Substituting into (1)

$$0 + 8 = \frac{1}{2}mv_{\max}^2 + 0;\ v_{\max}^2 = \frac{16}{m}$$

For $m = 1$ kg $\qquad v_{\max}^2 = 16 \qquad (a) \qquad v_{\max} = 4$ m/s ◀

For $m = 2.5$ kg $\qquad v_{\max}^2 = \frac{16}{2.5} = 6.4 \qquad (b) \qquad v_{\max} = 2.53$ m/s ◀

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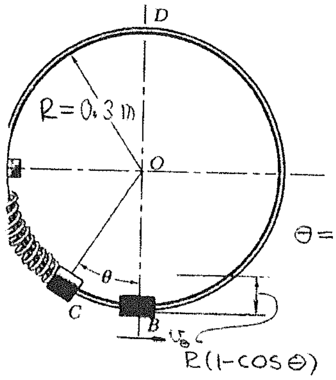
Chapter 13, Solution 69.



(a)

$v_C = 0, \qquad T_C = 0$

$$T_B = \frac{1}{2} m v_B^2$$

$$T_B = \frac{1}{2}(0.2 \text{ kg}) v_B^2$$

$T_B = 0.1 v_B^2 \qquad V_C = (V_C)_e + (V_C)_g$

$$\text{arc } BC = \Delta L_{BC} = R\theta$$

$$\Delta L_{BC} = (0.3 \text{ m})(30°)\frac{(\pi)}{180°}$$

$$\Delta L_{BC} = 0.15708 \text{ m}$$

$$(V_C)_e = \frac{1}{2} k (\Delta L_{BC})^2 = \frac{1}{2}(40 \text{ N/m})(0.15708 \text{ m})^2 = 0.49348 \text{ J}$$

$$(V_C)_g = WR(1 - \cos\theta) = (0.2 \text{ kg})(9.81 \text{ m/s}^2)(0.3 \text{ m})(1 - \cos 30°)$$

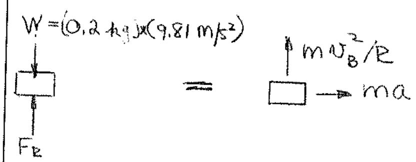
$$(V_C)_g = 0.078857 \text{ J}$$

$$V_C = (V_C)_e + (V_C)_g = 0.49348 \text{ J} + 0.078857 \text{ J} = 0.57234 \text{ J}$$

$$V_B = (V_B)_e + (V_B)_g = 0 + 0 = 0$$

$$T_C + V_C = T_B + V_B; \qquad 0 + 0.57234 = 0.1 v_B^2$$

$v_B^2 = 5.7234 \text{ m}^2/\text{s}^2 \qquad v_B = 2.39 \text{ m/s}$ ◀



(b)

$$+\uparrow \Sigma F = F_R - W = \frac{m v_B^2}{R}$$

$$F_R = 1.962 \text{ N} + (0.2 \text{ kg})\frac{(5.7234 \text{ m}^2/\text{s}^2)}{(0.3 \text{ m})}$$

$F_R = 1.962 \text{ N} + 3.8156 \text{ N} = 5.7776 \text{ N} \qquad F_R = 5.78 \text{ N} \uparrow$ ◀

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