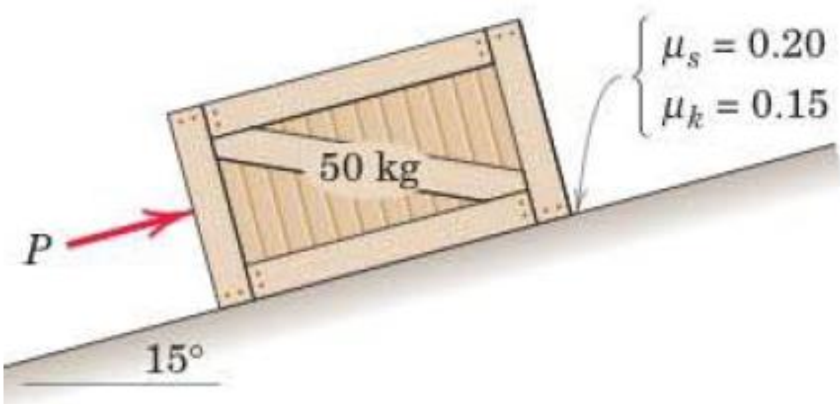
Engineering Mechanics
AGE 2330

Lect 13: Review of Lect 11

Dr. Feras Fraige

3/2 The 50-kg crate is stationary when the force P is applied. Determine the resulting acceleration of the crate if (*a*) $P = 0$, (*b*) $P = 150$ N, and (*c*) $P = 300$ N.



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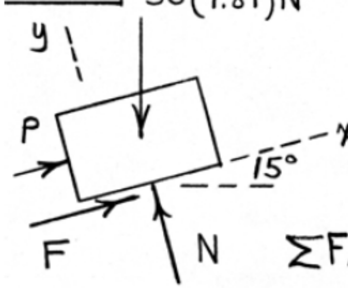


$\Sigma F_y = 0: \; N - 50(9.81)\cos 15° = 0$

$N = 474$ N throughout

(a) $P = 0$

Equilibrium check:

$\Sigma F_x = 0: \; F - 50(9.81)\sin 15° = 0$

$F = 127.0$ N

$F_{max} = \mu_s N = 0.2(474) = 94.8 \text{ N} < F$: motion ↙

$\Sigma F_x = ma_x: \; 0.15(474) - 50(9.81)\sin 15° = 50 a_x$

$\underline{a_x = -1.118 \text{ m/s}^2}$

(b) $P = 150$ N; Equilibrium check:

$\Sigma F_x = 0: \; 150 + F - 50(9.81)\sin 15° = 0$

$F = -23.0$ N, $|F| < F_{max}$ so no motion: $\underline{a = 0}$

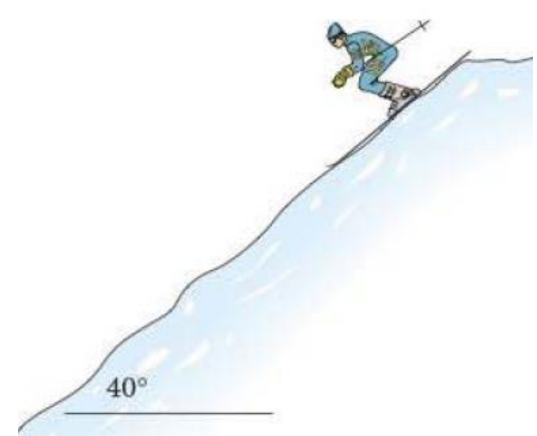
(c) $P = 300$ N; Equilibrium check yields $F = -173.0$ N

$|F| > F_{max}$, so motion ↗, $F = F_k$ ↙.

$\Sigma F_x = ma_x: \; 300 - 0.15(474) - 50(9.81)\sin 15° = 50 a_x$

$\underline{a_x = 2.04 \text{ m/s}^2}$

3/6 A skier starts from rest on the 40° slope at time $t = 0$ and is clocked at $t = 2.58$ s as he passes a speed check-point 20 m down the slope. Determine the coefficient of kinetic friction between the snow and the skis. Neglect wind resistance.



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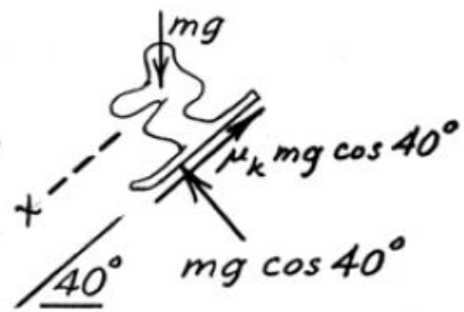
$$\Sigma F_x = ma_x: \; mg \sin 40° - \mu_k mg \cos 40° = ma$$



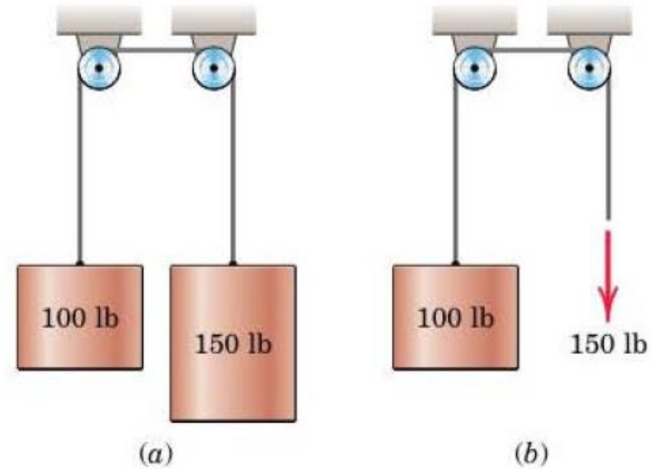
$$a = 9.81(\sin 40° - \mu_k \cos 40°)$$
$$= 6.31 - 7.51\mu_k$$

For constant accel. $s = v_0 t + \frac{1}{2}at^2$:

$$20 = 0 + \frac{1}{2}(6.31 - 7.51\mu_k)2.58^2$$

$$\underline{\mu_k = 0.0395}$$

3/7 Calculate the vertical acceleration a of the 100-lb cylinder for each of the two cases illustrated. Neglect friction and the mass of the pulleys.



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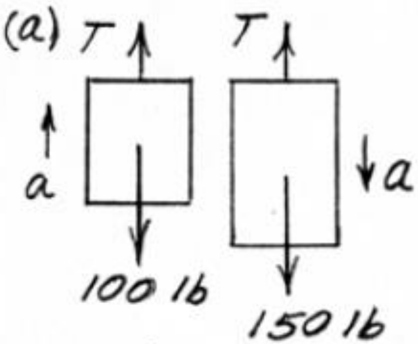
$\Sigma F = ma; \quad T - 100 = \frac{100}{32.2} a$

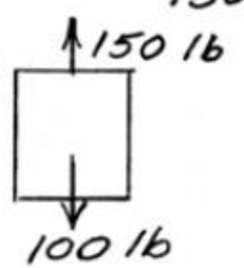
(a)



$150 - T = \frac{150}{32.2} a$

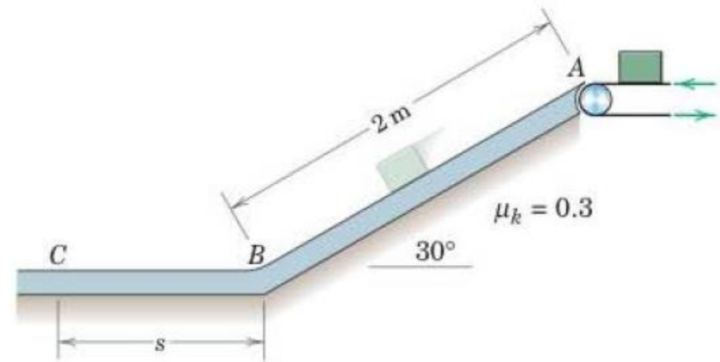
$50 = \frac{250}{32.2} a, \quad a = \frac{32.2}{5} = 6.44 \frac{ft}{sec^2}$

(b)



$150 - 100 = \frac{100}{32.2} a, \quad a = \frac{32.2}{2} = 16.10 \frac{ft}{sec^2}$

3/16 A small package is deposited by the conveyor belt onto the 30° ramp at A with a velocity of 0.8 m/s. Calculate the distance s on the level surface BC at which the package comes to rest. The coefficient of kinetic friction for the package and supporting surface from A to C is 0.3.



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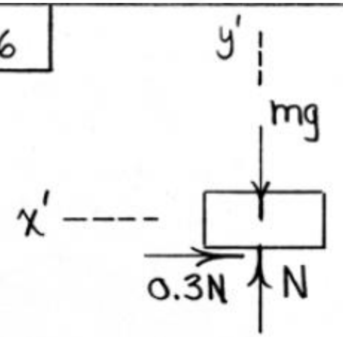
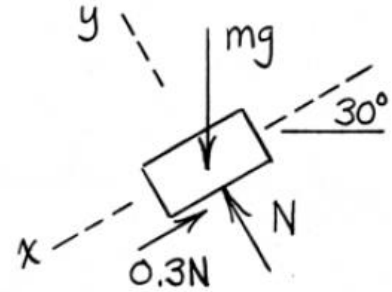




A to B:

$\Sigma F_y = 0 \Rightarrow \quad N = 0.866\, mg$

$\Sigma F_x = ma_x: \quad mg \sin 30° - 0.3(0.866\, mg) = ma$

$a_x = 2.36 \text{ m/s}^2$

$v_B^2 = v_A^2 + 2a_x d: \quad v_B^2 = 0.8^2 + 2(2.36)(2)$

$v_B = 3.17 \text{ m/s}$

B to C:

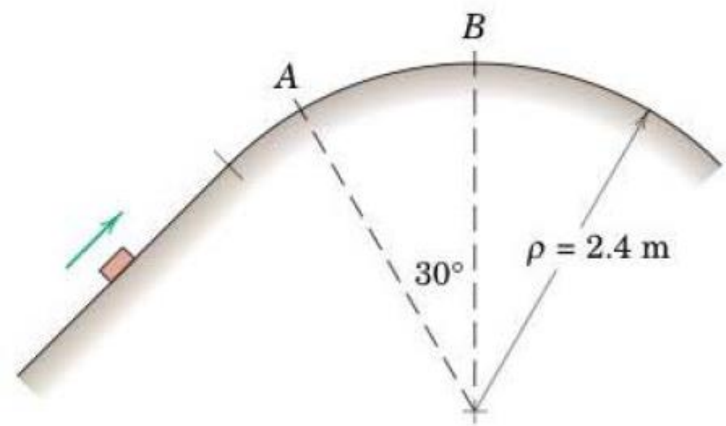
$\Sigma F_{y'} = 0 \Rightarrow \quad N = mg$

$\Sigma F_{x'} = ma_{x'}: \quad -0.3(mg) = ma_{x'}, \quad a_{x'} = -2.94 \text{ m/s}^2$

$v_C^2 = v_B^2 + 2a_{x'} s: \quad 0 = 3.17^2 - 2(2.94)s$

$\underline{s = 1.710 \text{ m}}$

3/51 If the 2-kg block passes over the top B of the circular portion of the path with a speed of 3.5 m/s, calculate the magnitude N_B of the normal force exerted by the path on the block. Determine the maximum speed v which the block can have at A without losing contact with the path.



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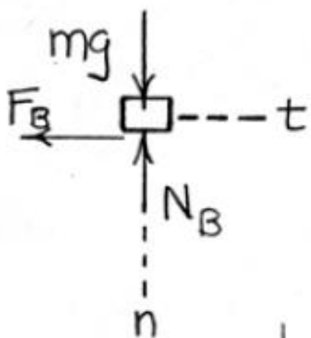
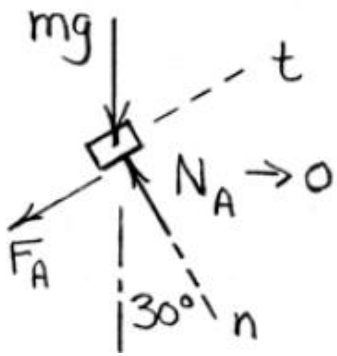


$$\Sigma F_n = ma_n = m\frac{v^2}{\rho}:$$

$$2(9.81) - N = 2\,\frac{3.5^2}{2.4}$$

$$\underline{N_B = 9.41\ \text{N}}$$

Loss of contact at A: $N_A \to 0$

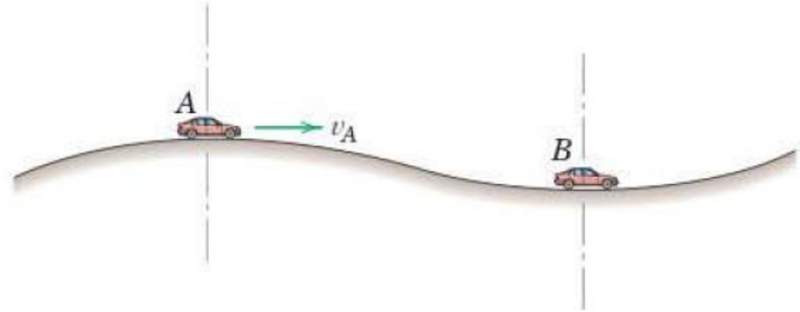


$$\Sigma F_n = ma_n = m\frac{v^2}{\rho}:$$

$$\cancel{m}g\cos 30^\circ = \cancel{m}\frac{v^2}{2.4}$$

$$\underline{v = 4.52\ \text{m/s}}$$

3/55 The car passes over the top of a vertical curve at A with a speed of 60 km/h and then passes through the bottom of a dip at B. The radii of curvature of the road at A and B are both 100 m. Find the speed of the car at B if the normal force between the road and the tires at B is twice that at A. The mass center of the car is 1 meter from the road.



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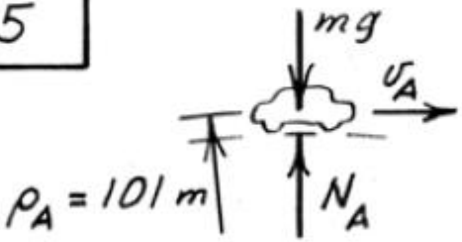
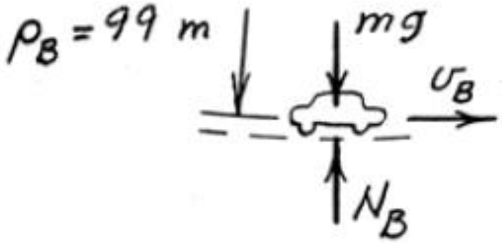




$\Sigma F_n = ma_n$:

A: $mg - N_A = m\dfrac{v_A^2}{\rho_A}$ $\quad$ B: $N_B - mg = m\dfrac{v_B^2}{\rho_B}$

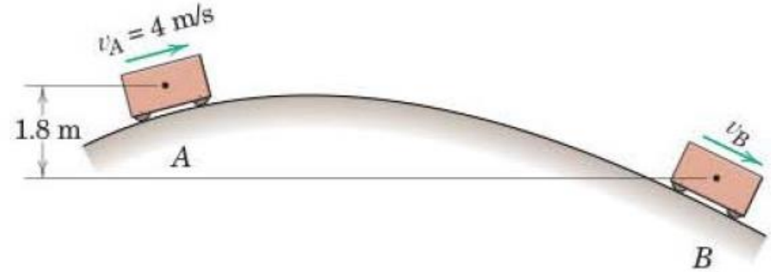
For $N_B = 2N_A$, $m\left(\dfrac{v_B^2}{\rho_B} + g\right) = 2m\left(g - \dfrac{v_A^2}{\rho_A}\right)$

$$v_B^2 = \rho_B g - 2v_A^2\frac{\rho_B}{\rho_A} = 99(9.81) - 2\left(\frac{60\times1000}{3600}\right)^2\frac{99}{101}$$

$$= 427 \text{ m}^2/\text{s}^2$$

$v_B = 20.7$ m/s or $\underline{v_B = 74.4 \text{ km/h}}$

3/105 The small cart has a speed $v_A = 4$ m/s as it passes point A. It moves without appreciable friction and passes over the top hump of the track. Determine the cart speed as it passes point B. Is knowledge of the shape of the track necessary?



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$$T_A + U_{A-B} = T_B$$

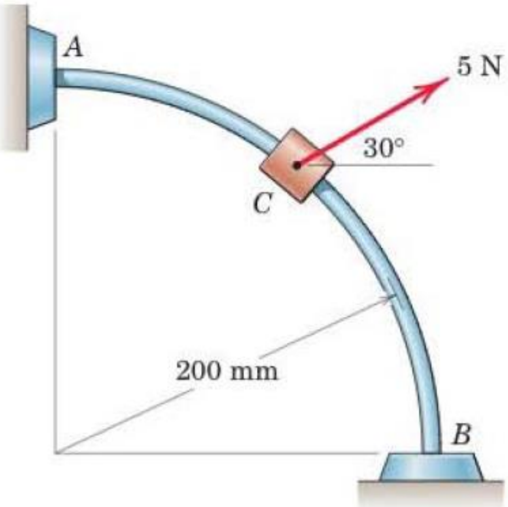
$$\frac{1}{2}\cancel{m}v_A^2 + \cancel{m}gh = \frac{1}{2}\cancel{m}v_B^2$$

$$v_B^2 = v_A^2 + 2gh = 4^2 + 2(9.81)(1.8)$$

$$v_B = 7.16 \text{ m/s}$$

Knowledge of the shape of the track is unnecessary, as long as it is known that the cart passes the highest point.

3/107 The 0.5-kg collar C starts from rest at A and slides with negligible friction on the fixed rod in the vertical plane. Determine the velocity v with which the collar strikes end B when acted upon by the 5-N force, which is constant in direction. Neglect the small dimensions of the collar.



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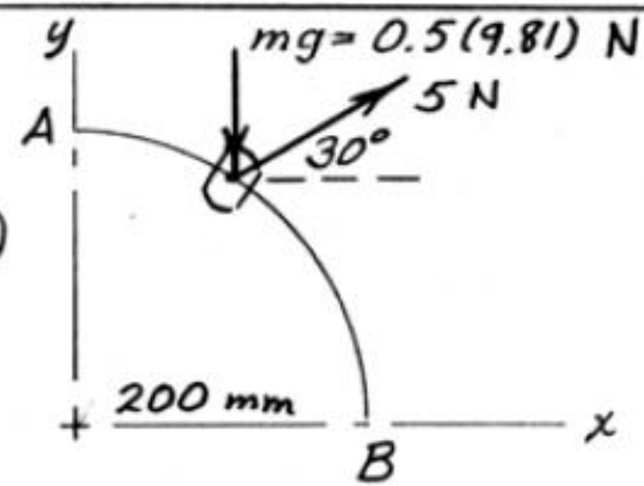
$U = \Delta T$: $5\cos 30°(0.2) - 5\sin 30°(0.2)$

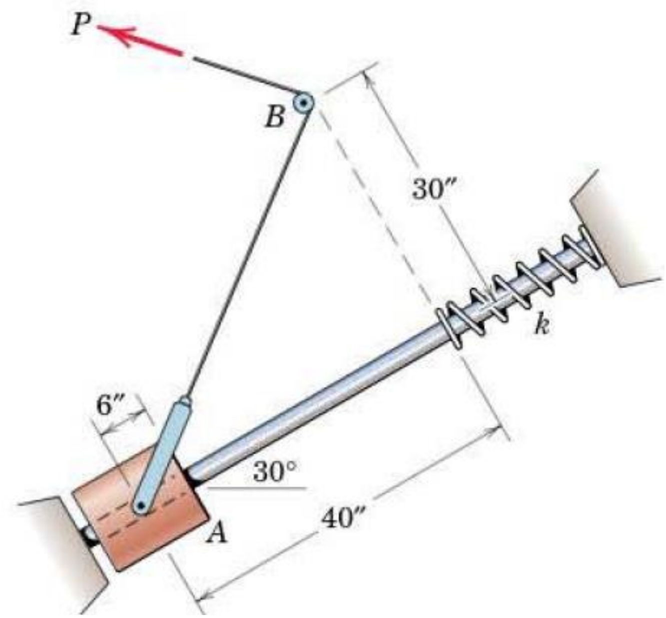
$+0.5(9.81)(0.2)$

$= \frac{1}{2}0.5(v^2 - 0)$



$v^2 = 5.39\ (\text{m/s})^2$, $\underline{v = 2.32\ \text{m/s}}$

3/110 The 30-lb collar A is released from rest in the position shown and slides with negligible friction up the fixed rod inclined 30° from the horizontal under the action of a constant force $P = 50$ lb applied to the cable. Calculate the required stiffness k of the spring so that its maximum deflection equals 6 in. The position of the small pulley at B is fixed.



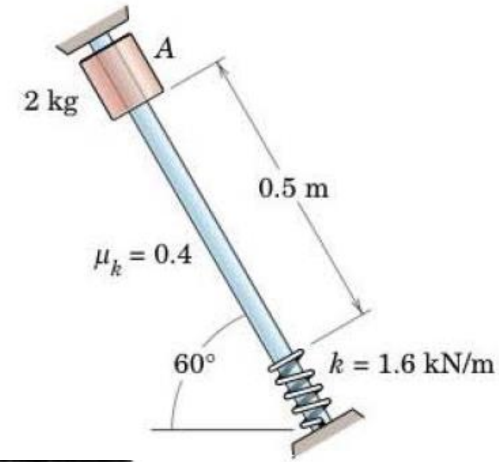
- Convert in to ft using
- 1′ (ft) = 12′′ (in)

3/110 For collar, $U_{1-2} = \Delta T = 0$

$$U_{1-2} = 50\left(\frac{50-30}{12}\right) - 30\,\frac{40}{12}\sin 30^\circ - \frac{1}{2}k\left(\frac{6}{12}\right)^2 = 0$$

$\underline{k = 267 \text{ lb/ft}}$

3/116 The 2-kg collar is released from rest at A and slides down the inclined fixed rod in the vertical plane. The coefficient of kinetic friction is 0.4. Calculate (a) the velocity v of the collar as it strikes the spring and (b) the maximum deflection x of the spring.



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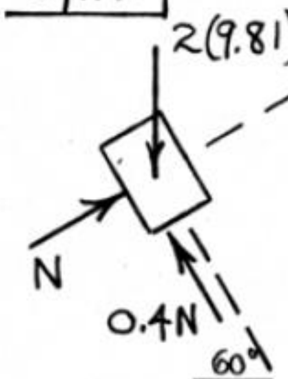

$\Sigma F_y = 0: \quad N - 2(9.81)\cos 60° = 0$

$N = 9.81$ N

(a) $U_{1\text{-}2} = \Delta T: \quad 2(9.81)(0.5 \sin 60°) - 0.4(9.81)(0.5) = \frac{1}{2}\, 2\, v^2$

$\underline{v = 2.56 \text{ m/s}}$

(b) $U_{1\text{-}3} = \Delta T: \quad 2(9.81)(0.5+x)\sin 60° - 0.4(9.81)(0.5+x) - \frac{1}{2}(1600)x^2 = 0$

$800x^2 - 13.07x - 6.53 = 0$

$x = 0.0989$ m or $\underline{x = 98.9 \text{ mm}}$