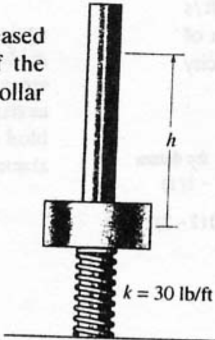
14-74. The collar has a weight of 8 lb. If it is released from rest at a height of $h = 2$ ft from the top of the uncompressed spring, determine the speed of the collar after it falls and compresses the spring 0.3 ft.

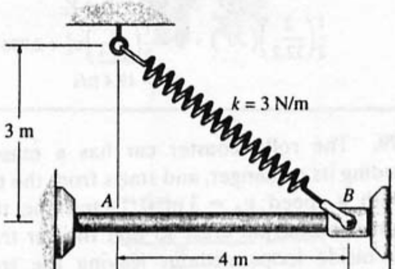


$$T_1 + V_1 = T_2 + V_2$$

$$0 + 0 = \frac{1}{2}\left(\frac{8}{32.2}\right)v_2^2 - 8(2.3) + \frac{1}{2}(30)(0.3)^2$$

$$v_2 = 11.7 \text{ ft/s} \qquad \textbf{Ans}$$

14-75. The 2-kg collar is attached to a spring that has an unstretched length of 3 m. If the collar is drawn to point B and released from rest, determine its speed when it arrives at point A.



Potential Energy : The initial and final elastic potential energy are $\frac{1}{2}(3)\left(\sqrt{3^2+4^2}-3\right)^2 = 6.00$ J and $\frac{1}{2}(3)(3-3)^2 = 0$, respectively. The gravitational potential energy remains the same since the elevation of collar does not change when it moves from B to A.

Conservation of Energy :

$$T_B + V_B = T_A + V_A$$

$$0 + 6.00 = \frac{1}{2}(2)\,v_A^2 + 0$$

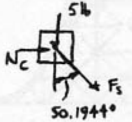
$$v_A = 2.45 \text{ m/s} \qquad \textbf{Ans}$$

14-77. The 5-lb collar is released from rest at A and travels along the smooth guide. Determine its speed when its center reaches point C and the normal force it exerts on the rod at this point. The spring has an unstretched length of 12 in., and point C is located just before the end of the curved portion of the rod.

$$T_A + V_A = T_C + V_C$$

$$0 + 0 + \frac{1}{2}[2(12)](\frac{10}{12})^2 + 5(\frac{12}{12}) = \frac{1}{2}(\frac{5}{32.2})v^2 + \frac{1}{2}[2(12)](\sqrt{(\frac{12}{12})^2 + (\frac{10}{12})^2} - \frac{12}{12}]^2$$

$v = 12.556$ ft/s $= 12.6$ ft/s **Ans**



$\overset{+}{\rightarrow} \Sigma F_n = m\,a_n;$ $\quad N_C + F_s \sin 50.1944° = \frac{5}{32.2}(\frac{(12.556)^2}{1})$

$F_s = ks;$ $\quad F_s = 2(12)[\sqrt{(\frac{12}{12})^2 + (\frac{10}{12})^2} - \frac{12}{12}] = 7.2410$ lb

Thus,

$N_C = 18.9$ lb **Ans**

***15-4.** The 180-lb iron worker is secured by a fall-arrest system consisting of a harness and lanyard AB, which is fixed to the beam. If the lanyard has a slack of 4 ft, determine the average impulsive force developed in the lanyard if he happens to fall 4 feet. Neglect his size in the calculation and assume the impulse takes place in 0.6 seconds.

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

$$0 + 180(4) = \frac{1}{2}\left(\frac{180}{32.2}\right)v^2$$

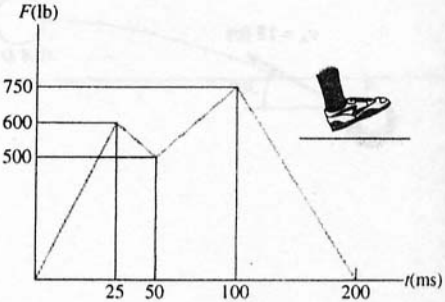
$$v = 16.05 \text{ ft/s}$$

$$(+\downarrow) \qquad mv_1 + \int F\,dt = mv_2$$

$$\frac{180}{32.2}(16.05) + 180(0.6) - F(0.6) = 0$$

$$F = 329.5 \text{ lb} = 330 \text{ lb} \qquad \textbf{Ans}$$

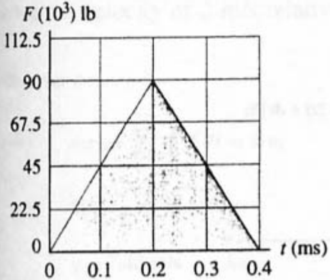
15-5. The graph shows the vertical reaction force of the shoe-ground interaction as a function of time. The first peak acts on the heel, and the second peak acts on the forefoot. Determine the total impulse acting on the shoe during the interaction.



Impulse : The total impluse acting on the shoe can be obtained by evaluating the area under the $F-t$ graph.

$$I = \frac{1}{2}(600)\left[25\left(10^{-3}\right)\right] + \frac{1}{2}(500+600)(50-25)\left(10^{-3}\right)$$
$$+\frac{1}{2}(500+750)(100-50)\left(10^{-3}\right) + \frac{1}{2}(750)\left[(200-100)\left(10^{-3}\right)\right]$$
$$= 90.0 \text{ lb}\cdot\text{s} \qquad \textbf{Ans}$$

***15-8.** During operation the breaker hammer develops on the concrete surface a force which is indicated in the graph. To achieve this the 2-lb spike S is fired from rest into the surface at 200 ft/s. Determine the speed of the spike just after rebounding.



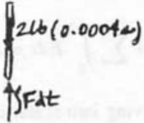
$(+\downarrow)$ $\quad mv_1 + \int F\,dt = mv_2$

$$\frac{2}{32.2}(200) + 2(0.0004) - Area = \frac{-2}{32.2}(v)$$

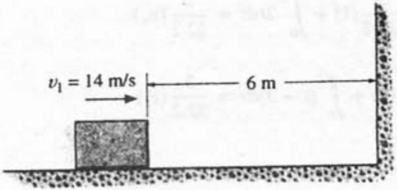
$$Area = \frac{1}{2}(90)(10^3)(0.4)(10^{-3}) = 18 \text{ lb}\cdot\text{s}$$

Thus,

$v = 89.8$ ft/s $\qquad$ **Ans**



15-9. When the 5-kg block is 6 m from the wall, it is sliding at $v_1 = 14$ m/s. If the coefficient of kinetic friction between the block and the horizontal plane is $\mu_k = 0.3$, determine the impulse of the wall on the block necessary to stop the block. Neglect the friction impulse acting on the block during the collision.



Equation of Motion : The acceleration of the block must be obtained first before one can determine the velocity of the block before it strikes the wall.

$$+\uparrow \Sigma F_y = ma_y; \quad N - 5(9.81) = 5(0) \quad N = 49.05 \text{ N}$$

$$\overset{+}{\rightarrow} \Sigma F_x = ma_x; \quad -0.3(49.05) = -5a \quad a = 2.943 \text{ m/s}^2$$

Kinematics : Applying the equation $v^2 = v_0^2 + 2a_c(s - s_0)$ yields

$$(\overset{+}{\rightarrow}) \quad v^2 = 14^2 + 2(-2.943)(6-0) \quad v = 12.68 \text{ m/s}$$

Principle of Linear Impulse and Momentum : Applying Eq. 15 – 4, we have

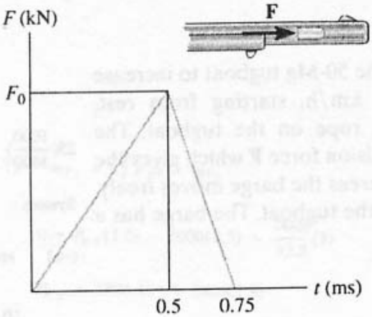
$$m(v_x)_1 + \Sigma\int_{t_1}^{t_2} F_x\,dt = m(v_x)_2$$

$$(\overset{+}{\rightarrow}) \quad 5(12.68) - I = 5(0)$$

$$I = 63.4 \text{ N}\cdot\text{s}$$

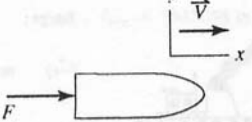
Ans

15-13. Assuming that the force acting on a 2-g bullet, as it passes horizontally through the barrel of a rifle, varies with time in the manner shown, determine the maximum net force F_0, applied to the bullet when it is fired. The muzzle velocity is 500 m/s when $t = 0.75$ ms. Neglect friction between the bullet and the rifle barrel.



Principle of Linear Impulse and Momentum: The total impluse acting on the bullet can be obtained by evaluating the area under the $F - t$ graph. Thus, $I = \sum \int_{t_1}^{t_2} F_x dt = \frac{1}{2}(F_0)[0.5(10^{-3})] + \frac{1}{2}(F_0)[(0.75 - 0.5)(10^{-3})] = 0.375(10^{-3})F_0$. Applying Eq. 15-4, we have

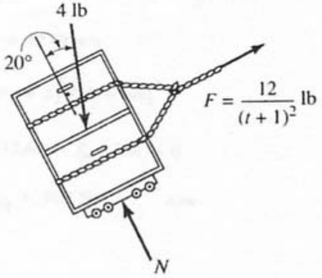
$$m(v_x)_1 + \sum \int_{t_1}^{t_2} F_x dt = m(v_k)_2$$



$(\overset{+}{\rightarrow})$ $$0 + 0.375(10^{-3})F_0 = 2(10^{-3})(500)$$

$$F_0 = 2666.67 \text{ N} = 2.67 \text{ kN}$$ **Ans**

15-15. The 4-lb cabinet is subjected to the force $F = 12(t + 1)^2$ lb where t is in seconds. If the cabinet is initially moving up the plane with a velocity of 10 ft/s, determine how long it will take before the cabinet comes to a stop. F always acts parallel to the plane. Neglect the size of the rollers.



Principle of Linear Impulse and Momentum: Applying Eq. 15-4, we have

$$m(v_{x'})_1 + \sum \int_{t_1}^{t_2} F_{x'}\,dt = m(v_{x'})_2$$

$$\left(\frac{4}{32.2}\right)(10) + \int_0^t \frac{12}{(t+1)^2}dt - 4\sin 20°t = \left(\frac{4}{32.2}\right)(0)$$

$t = 8.78$ s **Ans**