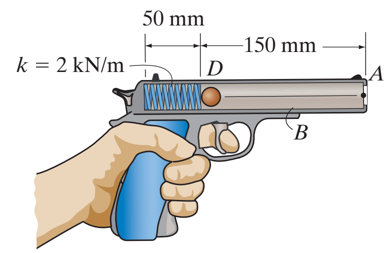
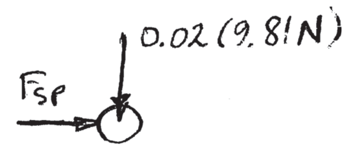
14–6.

The spring in the toy gun has an unstretched length of 100 mm. It is compressed and locked in the position shown. When the trigger is pulled, the spring unstretches 12.5 mm, and the 20-g ball moves along the barrel. Determine the speed of the ball when it leaves the gun. Neglect friction.



SOLUTION

Principle of Work and Energy: Referring to the free-body diagram of the ball bearing shown in Fig. *a*, notice that $\mathbf{F}_{sp}$ does positive work. The spring has an initial and final compression of $s_1 = 0.1 - 0.05 = 0.05$ m and $s_2 = 0.1 - (0.05 + 0.0125) = 0.0375$ m.



(a)

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

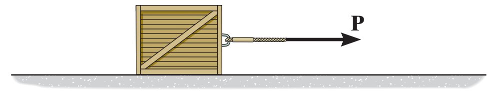
$$0 + \left[\frac{1}{2}ks_1^{\,2} - \frac{1}{2}ks_2^{\,2}\right] = \frac{1}{2}mv_A^{\,2}$$

$$0 + \left[\frac{1}{2}(2000)(0.05)^2 - \frac{1}{2}(2000)(0.0375^2)\right] = \frac{1}{2}(0.02)v_A^{\,2}$$

$$v_A = 10.5 \text{ m/s}$$ **Ans.**

14–9.

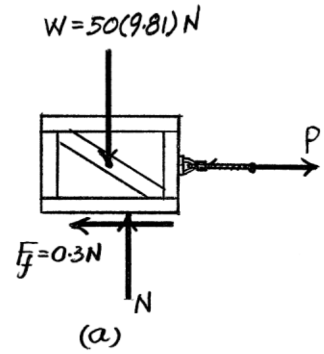
If the 50-kg crate starts from rest and attains a speed of 6 m/s when it has traveled a distance of 15 m, determine the force **P** acting on the crate. The coefficient of kinetic friction between the crate and the ground is $\mu_k = 0.3$.



SOLUTION

Free-Body Diagram: Referring to the free-body diagram of the crate, Fig. *a*,

$+\uparrow F_y = ma_y; \quad N - 50(9.81) = 50(0) \quad N = 490.5 \text{ N}$



Thus, the frictional force acting on the crate is $F_f = \mu_k N = 0.3(490.5) = 147.15$ N.

Principle of Work and Energy: Referring to Fig. *a*, only **P** and $\mathbf{F}_f$ do work. The work of **P** will be positive, whereas $\mathbf{F}_f$ does negative work.

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

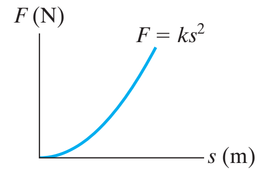
$$0 + P(15) - 147.15(15) = \frac{1}{2}(50)(6^2)$$

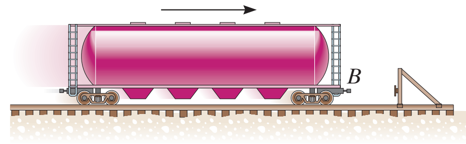
$$P = 207 \text{ N}$$

Ans.

***14–12.**

Design considerations for the bumper B on the 5-Mg train car require use of a nonlinear spring having the load-deflection characteristics shown in the graph. Select the proper value of k so that the maximum deflection of the spring is limited to 0.2 m when the car, traveling at 4 m/s, strikes the rigid stop. Neglect the mass of the car wheels.



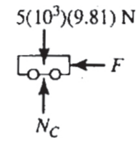


SOLUTION

$$\frac{1}{2}(5000)(4)^2 - \int_0^{0.2} ks^2\,ds = 0$$

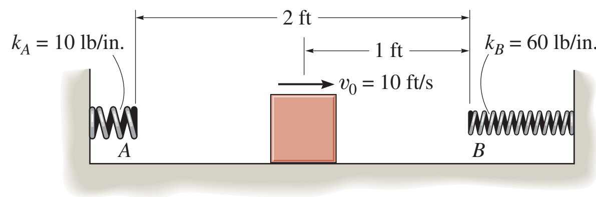
$$40\,000 - k\frac{(0.2)^3}{3} = 0$$

$$k = 15.0\ \text{MN/m}^2$$ **Ans.**



14–22.

The 25-lb block has an initial speed of $v_0 = 10$ ft/s when it is midway between springs A and B. After striking spring B, it rebounds and slides across the horizontal plane toward spring A, etc. If the coefficient of kinetic friction between the plane and the block is $\mu_k = 0.4$, determine the total distance traveled by the block before it comes to rest.



SOLUTION

Principle of Work and Energy: Here, the friction force $F_f = \mu_k N = 0.4(25) = 10.0$ lb. Since the friction force is always opposite the motion, it does negative work. When the block strikes spring B and stops momentarily, the spring force does *negative* work since it acts in the opposite direction to that of displacement. Applying Eq. 14–7, we have

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

$$\frac{1}{2}\left(\frac{25}{32.2}\right)(10)^2 - 10(1 + s_1) - \frac{1}{2}(60)s_1^2 = 0$$

$$s_1 = 0.8275 \text{ ft}$$

Assume the block bounces back and stops without striking spring A. The spring force does *positive* work since it acts in the direction of displacement. Applying Eq. 14–7, we have

$$T_2 + \sum U_{2-3} = T_3$$

$$0 + \frac{1}{2}(60)(0.8275^2) - 10(0.8275 + s_2) = 0$$

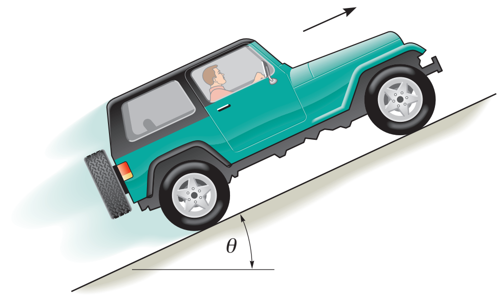
$$s_2 = 1.227 \text{ ft}$$

Since $s_2 = 1.227 \text{ ft} < 2 \text{ ft}$, the block stops before it strikes spring A. Therefore, the above assumption was correct. Thus, the total distance traveled by the block before it stops is

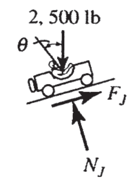
$$s_{\text{Tot}} = 2s_1 + s_2 + 1 = 2(0.8275) + 1.227 + 1 = 3.88 \text{ ft} \qquad \textbf{Ans.}$$

14–42.

The jeep has a weight of 2500 lb and an engine which transmits a power of 100 hp to *all* the wheels. Assuming the wheels do not slip on the ground, determine the angle θ of the largest incline the jeep can climb at a constant speed $v = 30$ ft/s.



SOLUTION



$P = F_J v$

$100(550) = 2500 \sin \theta(30)$

$\theta = 47.2°$ **Ans.**