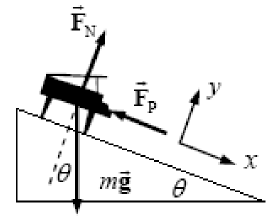
11. The piano is moving with a constant velocity down the plane. $\vec{\mathbf{F}}_P$ is the force of the man pushing on the piano.




(*a*) Write Newton's second law on each direction for the piano, with an acceleration of 0.

$$\sum F_y = F_N - mg\cos\theta = 0 \quad \rightarrow \quad F_N = mg\cos\theta$$

$$\sum F_x = mg\sin\theta - F_P = 0 \quad \rightarrow$$

$$F_P = mg\sin\theta = mg\sin\theta$$

$$= (380\,\text{kg})(9.80\,\text{m/s}^2)(\sin 27^\circ) = 1691\,\text{N} \approx \boxed{1700\,\text{N}}$$

(*b*) The work done by the man is the work done by $\vec{\mathbf{F}}_P$. The angle between $\vec{\mathbf{F}}_P$ and the direction of motion is 180°. Use Eq. 7-1.

$$W_P = F_P d\cos 180^\circ = -(1691\,\text{N})(3.9\,\text{m}) = -6595\,\text{J} \approx \boxed{-6600\,\text{J}}.$$

(*c*) The angle between the force of gravity and the direction of motion is 63°. Calculate the work done by gravity.

$$W_G = F_G d\cos 63^\circ = mgd\cos 63^\circ = (380\,\text{kg})(9.80\,\text{m/s}^2)(3.9\,\text{m})\cos 63^\circ$$

$$= 6594\,\text{N} \approx \boxed{6600\,\text{J}}$$

(*d*) Since the piano is not accelerating, the net force on the piano is 0, and so the net work done on the piano is also 0. This can also be seen by adding the two work amounts calculated.

$$W_{\text{net}} = W_P + W_G = -6.6\times10^3\,\text{J} + 6.6\times10^3\,\text{J} = \boxed{0\,\text{J}}$$

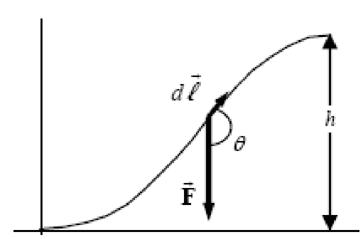
$\boxed{13.}$ (*a*) The gases exert a force on the jet in the same direction as the displacement of the jet. From the graph we see the displacement of the jet during launch is 85 m. Use Eq. 7-1 to find the work.

$$W_{\text{gas}} = F_{\text{gas}} d\cos 0^\circ = (130\times10^3\,\text{N})(85\,\text{m}) = \boxed{1.1\times10^7\,\text{J}}$$

(*b*) The work done by catapult is the area underneath the graph in Figure 7-22. That area is a trapezoid.

$$W_{\text{catapult}} = \tfrac{1}{2}(1100\times10^3\,\text{N} + 65\times10^3\,\text{N})(85\,\text{m}) = \boxed{5.0\times10^7\,\text{J}}$$

36. For a non-linear path, the work is found by considering the path to be an infinite number of infinitesimal (or differential) steps, each of which can be considered to be in a specific direction, namely, the direction tangential to the path. From the diagram, for each step we have $dW = \vec{\mathbf{F}}\cdot d\vec{\ell} = F\,d\ell\cos\theta$. But $d\ell\cos\theta = -dy$, the projection of the path in the direction of the force, and $F = mg$, the force of



40. The work done will be the area under the $F_x$ vs. $x$ graph.

(*a*) From $x = 0.0$ to $x = 10.0\,\text{m}$, the shape under the graph is trapezoidal. The area is

$$W_a = (400\,\text{N})\tfrac{1}{2}(10\,\text{m} + 4\,\text{m}) = \boxed{2800\,\text{J}}.$$

(*b*) From $x = 10.0\,\text{m}$ to $x = 15.0\,\text{m}$, the force is in the opposite direction from the direction of motion, and so the work will be negative. Again, since the shape is trapezoidal, we find

$$W_a = (-200\,\text{N})\tfrac{1}{2}(5\,\text{m} + 2\,\text{m}) = -700\,\text{J}.$$

Thus the total work from $x = 0.0$ to $x = 15.0\,\text{m}$ is $2800\ \text{J} - 700\ \text{J} = \boxed{2100\,\text{J}}$.

63. (*a*) The angle between the pushing force and the displacement is $32°$.

$$W_{\text{P}} = F_{\text{P}} d \cos\theta = (150\,\text{N})(5.0\,\text{m})\cos 32° = 636.0\,\text{J} \approx \boxed{640\,\text{J}}$$

(*b*) The angle between the force of gravity and the displacement is $122°$.

$$W_{\text{G}} = F_{\text{G}} d \cos\theta = mgd\cos\theta = (18\,\text{kg})(9.80\,\text{m/s}^2)(5.0\,\text{m})\cos 122° = -467.4\,\text{J} \approx \boxed{-470\,\text{J}}$$

(*c*) Because the normal force is perpendicular to the displacement, the work done by the normal force is $\boxed{0}$.

(*d*) The net work done is the change in kinetic energy.

$$W = W_{\text{P}} + W_{\text{g}} + W_{\text{N}} = \Delta K = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}mv_i^2 \quad \rightarrow$$

$$v_f = \sqrt{\frac{2W}{m}} = \sqrt{\frac{2(636.0\,\text{J} - 467.4\,\text{J})}{(18\,\text{kg})}} = \boxed{4.3\,\text{m/s}}$$