The following equations, physical constants, and relationships may be useful.

1 mile = 1609 meters  
1 foot = 0.3048 m  
1 foot = 12 inches  
1 year = 365 days  
1 day = 24 hours  
1 hour = 3600 s  
$g = 9.8 \text{ m/s}^2$  
$\rho = \frac{m}{V}$  
$\Delta x = x_2 - x_1$  
$v = v_0 + at$

\[ v_{avg} = \frac{x_2 - x_1}{t_2 - t_1} \quad s_{avg} = \frac{\text{total distance}}{\text{total time}} \quad v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} \quad a_{avg} = \frac{\Delta v}{\Delta t} \quad a = \frac{dv}{dt} = \frac{d^2x}{dt^2} \]

\[ x - x_0 = v_0 t + \frac{1}{2} at^2 \]

\[ u^2 = u_0^2 + 2a(x - x_0) \quad x - x_0 = \frac{1}{2}(v_0 + v)t \quad x - x_0 = vt - \frac{1}{2} at^2 \]

\[ a_x = a \cos \theta \quad a_y = a \sin \theta \quad a = \sqrt{a_x^2 + a_y^2} \quad \tan \theta = \frac{a_y}{a_x} \quad \vec{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k} \]

\[ r_x = a_x + b_x, \quad r_y = a_y + b_y, \quad r_z = a_z + b_z \quad \vec{a} \cdot \vec{b} = ab \cos \phi \quad \vec{a} \times \vec{b} = \vec{c} \quad \text{where } c = ab \sin \phi \]

\[ \vec{a} = (a_x \hat{i} + a_y \hat{j} + a_z \hat{k}) \quad \vec{b} = (b_x \hat{i} + b_y \hat{j} + b_z \hat{k}) \quad \vec{a} \times \vec{b} = (a_y b_z - a_z b_y) \hat{i} - (a_x b_z - a_z b_x) \hat{j} + (a_x b_y - a_y b_x) \hat{k} \]

\[ \Delta \vec{r} = \vec{r}_2 - \vec{r}_1 \quad \Delta \vec{r} = (x_2 - x_1) \hat{i} + (y_2 - y_1) \hat{j} + (z_2 - z_1) \hat{k} = \Delta x \hat{i} + \Delta y \hat{j} + \Delta z \hat{k} \]

\[ \vec{v}_{avg} = \frac{\Delta \vec{r}}{\Delta t} \quad \vec{v} = \frac{d \vec{r}}{dt} \quad \vec{v} = v_x \hat{i} + v_y \hat{j} + v_z \hat{k} \quad \vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t} \quad \vec{a} = \frac{d \vec{v}}{dt} \]

\[ a = a_x \hat{i} + a_y \hat{j} + a_z \hat{k} \quad x - x_0 = (v_0 \cos \theta_0) t \quad y - y_0 = (v_0 \sin \theta_0) t - \frac{1}{2} gt^2 \quad \vec{v}_y = v_0 \sin \theta_0 - gt \]

\[ v_y^2 = (v_0 \sin \theta_0)^2 - 2g(y - y_0) \quad \vec{v}_{PA} = \vec{v}_{PB} + \vec{v}_{BA} \quad \text{Circumference of Circle } = 2\pi r \]

\[ y = (\tan \theta_0) x - \frac{gx^2}{2(v_0 \cos \theta_0)^2} \quad R = \frac{v_0^2}{g} \sin 2\theta_0 \quad a = \frac{v^2}{r} \quad T = \frac{2\pi r}{v} \]

If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

\[ \vec{F}_{net} = m\vec{a} \quad \vec{F}_{net,x} = \max \quad \vec{F}_{net,y} = \may \quad \vec{F}_{net,z} = \maz \quad \vec{F}_g = mg \quad \vec{W} = mg \quad \vec{F}_{BC} = -\vec{F}_{CB} \]

\[ f_{s,max} = \mu_s F_N \quad f_k = \mu_k F_N \quad D = \frac{1}{2} C_p A v^2 \quad v_i = \sqrt{\frac{2E_i}{C_p A}} \quad a = \frac{v^2}{R} \quad F = \frac{mv^2}{R} \]

\[ K = \frac{1}{2} mv^2 \quad W = F d \cos \phi = \vec{F} \cdot \hat{d} \quad \Delta K = K_f - K_i = W \quad K_f = K_i + W \]

\[ W_g = mg d \cos \phi \quad \Delta K = K_f - K_i = W_a + W_g \quad \vec{F}_s = -k \vec{d} \quad F_x = -k \vec{x} \quad W_s = \frac{1}{2} k x_f^2 \]

\[ W = \int_{x_i}^{x_f} F(x) dx \quad \vec{F}_{avg} = \frac{W}{\Delta t} \quad P = \frac{dW}{dt} \quad P = F v \cos \phi = \vec{F} \cdot \vec{v} \]
Physics 2110 Quiz 6 v1

Please show all work for the problem. An answer without enough work shown to justify it will not receive credit even if it is correct. Calculators are allowed, but no notes or books. Please express your answers in the appropriate units.

Problem: A block with mass \( m = 12.0 \text{ kg} \) is pulled to the right 2.00 m along the level floor by an applied force \( \vec{F}_a \) acting at 30.0° to the horizontal, as shown. There is friction between the block and the floor. Initially the speed of the block is 1.20 m/s. After it has travelled the 2.00 m, its speed is 1.80 m/s. We know that \( F_a = 12.0 \text{ N} \).

a. What is the work done by the force of gravity on the block?

b. What is the work done by the normal force on the block?

c. What is the work done by the applied force \( \vec{F}_a \) on the block?

d. What is the work done by the kinetic friction on the block?

\[ \begin{align*}
\vec{F}_a & \rightarrow \\
\vec{F}_N & \perp \\
\vec{F}_K & \perp \\
\vec{F}_g & \downarrow
\end{align*} \]

The forces acting on the block are as labelled.
The direction of the displacement \( \vec{d} \) is as shown.

\[ \text{a. } W_g = \text{ work done by gravity} = F_g d \cos 90° = 0 \text{ J} \quad \text{since the angle between} \quad \vec{F}_g \quad \text{and} \quad \vec{d} \quad \text{is} \quad 90° \]

\[ \text{b. } W_{F_N} = \text{ work done by normal force} = F_N d \cos 90° = 0 \text{ J} \quad \text{since the angle between} \quad \vec{F}_N \quad \text{and} \quad \vec{d} \quad \text{is} \quad 90° \]

\[ \text{c. } W_a = \text{ work done by applied force} = F_a d \cos 30.0° \quad \text{since the angle between} \quad \vec{F}_a \quad \text{and} \quad \vec{d} \quad \text{is} \quad 30.0° \]

\[ W_a = (12.0 \text{N})(2.00 \text{m}) \cos 30.0° = 20.8 \text{ J} \]

\[ \text{d. } W_{F_K} = \text{ work done by kinetic friction} \]

\[ W = W_g + W_{F_N} + W_a + W_{F_K} = \Delta k = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \]

So

\[ W_a + W_{F_K} = \frac{1}{2} (12.0 \text{kg})(1.80 \text{m/s})^2 - \frac{1}{2} (12.0 \text{kg})(1.20 \text{m/s})^2 \]

\[ W_{F_K} = -W_a + 10.8 \text{ J} = -20.8 \text{ J} + 10.8 \text{ J} = -10.0 \text{ J} \]