PHYS 201 General Physics
Selected Solutions to the Final Exam Review Sheet

1. The arrow starts with a certain amount of kinetic energy, $1/2mv^2$. It finishes with a certain amount of potential energy, $mgh$. The difference is the energy lost due to air friction. In an equation:

$$KE(\text{initial}) + PE(\text{initial}) = KE(\text{final}) + PE(\text{final}) + \Delta Q$$

where $\Delta Q$ is the energy difference.

3. Free-body diagram:

The force of friction is just $f_k = \mu_k N = \mu_k mg$ since the weight and normal force are equal and opposite. Thus $f_k = (0.08)(20 \text{ kg})(9.8 \text{ m/s}^2) = 15.7 \text{ N}$.

The acceleration of the sled is found from Newton’s 2nd law: sum of forces = $ma$. The only horizontal force is friction, and we assume it points in the negative direction if we define “positive” as the direction of motion. So $a = F/m; a = (-15.7 \text{ N})/(20 \text{ kg}) = -0.78 \text{ m/s}^2$.

To find the distance, you can note that final velocity is zero, and use $v^2 = v_0^2 + 2a(x-x_o)$, obtaining 64 m.

4. Free-body diagram:

The frictional force is $f_k = \mu_k N$. To find $N$, we note that there is no acceleration along the $y$-axis, so

$$N - mg \cos 15^\circ = 0$$

Therefore

$$f_k = \mu_k mg \cos 15^\circ$$
The component of the weight \(mg\) along the x-axis is \(mg \sin 15^\circ\). Then we apply Newton’s second law, \(\Sigma F = ma\) in the x-direction.

\[
mg \sin 15^\circ - f_k = ma
\]

\[
mg \sin 15^\circ - \mu_k mg \cos 10^\circ = ma
\]

and solve for acceleration.

5. (A) Vertical component = \((15 \text{ m/s}) sin35^\circ = 8.60 \text{ m/s}\).

(B) Horizontal component = \((15 \text{ m/s}) cos35^\circ = 12.3 \text{ m/s}\).

(C) Use \(v_y = v_{oy} + at\), knowing that the final velocity in the y-direction is zero and \(a\) is -9.8 m/s\(^2\). Solve for \(t\), obtaining 0.88 s.

(D) We know that the total time will be twice the time it takes to reach his maximum height. (or solve \(y - y_o = v_{oy}t + \frac{1}{2}at^2\) with the displacement \(y - y_o\) equal to zero.) Then \(t = 1.76 \text{ s}\). The horizontal distance is \(x = v_x t\), giving us 21.6 m.

(D) You have to find the x- and y-components of the velocity at that time. Use

\[
v_y = v_{oy} + at
\]

and

\[
v_x = \text{a constant since } a_x = 0!
\]

We find \(v_y = 8.60 \text{ m/s} - 9.8 \text{ m/s} = -1.2 \text{ m/s}\) and \(v_x = 12.3 \text{ m/s}\). Using the Pythagorean theorem to add the vector components, the magnitude of the velocity is found to be 12.3 m/s to 3 significant figures. The x-component is actually 12.287 m/s if we don’t round off, and the magnitude is found to be 12.346 m/s, or 12.3 m/s. To find the angle use the fact that \(\tan \theta = v_y/v_x\). (Draw a diagram.) Taking the inverse tangent, we get 5.5 degrees. (Make sure your calculator is in degree mode, not radian mode.)

9. Free-body diagram:

\[\begin{array}{c}
T \\
\downarrow \\
25^\circ \\
\downarrow \\
mg
\end{array}\]

Since there is no acceleration vertically, \(T \cos 25^\circ = mg\), giving us 1.08 N. The horizontal component is then \(T \sin 25^\circ\) or 0.46 N. To find the acceleration, we use Newton’s second law along the x-axis. The sum of forces is just the horizontal component of the tension. So 0.46 N = \(ma\), giving us 4.5 m/s\(^2\).