The problems in this review are designed to help prepare you for your upcoming exam. Questions pertain to material covered in the course and are intended to reflect the topics likely to appear in the exam. Keep in mind that this worksheet was created by CARE tutors, and while it is thorough, it is not comprehensive. In addition to exam review sessions, CARE also hosts regularly scheduled tutoring hours.

1. (a) Below is a graph position versus time and its equation of an object traveling along some path described by: \( s(x) = \begin{cases} 
3 & t < 3 \\
x & t > 3 
\end{cases} \)

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{position_vs_time_graph}
\caption{Position versus time graph}
\end{figure}

i) What is the object’s velocity at time \( t = 2 \) s?

\[ \text{Velocity at } t = 2 \Rightarrow \frac{\Delta s}{\Delta t} = \frac{3 - 3}{2 - 0} = 0 \]

ii) What is the object’s velocity at time \( t = 5 \) s?

\[ \text{Velocity at } t = 5 \Rightarrow \frac{\Delta s}{\Delta t} = \frac{10 - 3}{5 - 3} = \frac{7}{2} \]

iii) When is the object accelerating?

\[ \text{Object is accelerating during } t > 3 \]

(b) Below is a graph velocity versus time and its equation of an object traveling along some path described by:

\[ v(x) = \begin{cases} 
-x & 0 < t \leq 5 \\
x & 5 < t \leq 10 \\
-10 & 10 < t \leq 15 
\end{cases} \]

i) If the object started at initial position \( x = 15 \) m, where does it end up after the whole 15 s?

ii) On which intervals of times is the object accelerating?

iii) On which intervals of times in the object decelerating?
2. A blue ball is thrown upward with an initial speed of $v_b = 20 \text{ m/s}$, from a height of $h_1 = 0.6$ meters above the ground. $t_d = 2.4$ seconds after the blue ball is thrown, a red ball is thrown down with an initial speed of $v_r = 8.7 \text{ m/s}$ from a height of $h_2 = 22.8$ meters above the ground. The force of gravity due to the earth results in the balls each having a constant downward acceleration of $g = 9.81 \text{ m/s}^2$

(a) What is the speed of the blue ball when it reaches its maximum height?

(b) How long does it take the blue ball to reach its maximum height?

(c) What is the maximum height of the blue ball?

(d) Write the position of the red ball as a function of time.

(e) When are the red ball and the blue ball at the same height?
3. A quarterback throws a football toward a receiver who catches it $t$ seconds later $D$ meters away. Assume the ball is thrown and caught at the same height above the horizontal field and that you can ignore air resistance.

(a) If $t = 3$ seconds and $D = 60$ m, what is the horizontal component $v_{0,x}$ of the initial velocity of the ball?

(b) If $t = 3$ seconds and $D = 60$ m, what is the maximum height $H$ reached by the ball (above its initial position)?
4. A boat is traveling directly across a river (as seen by an observer standing on the shore) that flows at a uniform rate of $v_{r,g} = 10$ ft/s, as shown in the figure. To compensate for the flow of the river, the boat must head upstream as it travels. The speed of the boat is 18 ft/s with respect to the water

(a) What is the angle between the direction the boat points and the direction it is traveling with respect to the shore?

(b) If the river has width, $W = 500$ ft, and the angle is $\theta = 50^\circ$:

   i) How long does it take the boat to reach the other side

   ii) How far upstream does the boat end up?
5. Three blocks are placed in contact on a horizontal frictionless surface. A constant force of magnitude $F = 30$ N is applied to the box of mass $M_1 = 8$kg. There is friction between the surfaces of blocks $M_2 = 2M_1$ and $M_3 = 3M_1$ ($\mu_s = 0.5, \mu_k = 0.3$) so the three blocks accelerated together to the right.

(a) What is the acceleration of the top block? Is it different than the acceleration of mass $M$?

(b) What is the maximum force $F$ that can be applied, before the $3M$ block slides off? (Hint: draw force diagrams for all three of the blocks)
6. Consider the following vertical spring system before and after a mass is attached:

After the mass, \( m \), is attached to the spring with spring constant \( k \) the spring stretches by some \( \Delta x \). Find an expression for \( \Delta x \) in terms of \( k \) and \( m \).
7. A block of mass $m = 1.5$ kg is kept in place on a rough ramp by a spring, as shown. The ramp makes an angle $\theta = 50^\circ$ with respect to the horizontal, and the coefficients of static and kinetic frictions are $\mu_s = 0.65$ and $\mu_k = 0.3$, respectively. The spring constant is $k = 40$ N/m.

What is $\Delta x_{\text{min}}$, the minimum amount the spring must be stretched in order for the block to be at rest?