Physics 107: Physics for Life-Sciences

Midterm Exam: September 21, 2015

This test is administered under the rules and regulations of the honor code of the College of William & Mary.

Name: _____

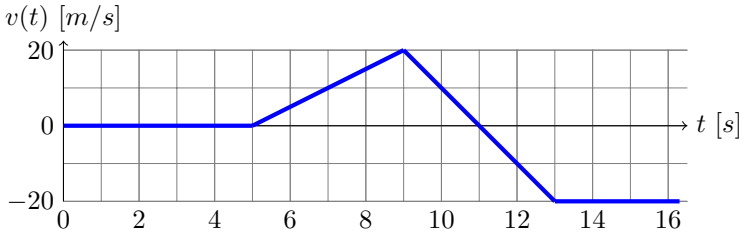
Signature: _____

Instructions:

- **This is a closed book, closed notes test.**
- **Calculators are NOT needed and NOT allowed. Devices with wireless connections are NOT allowed.**
- **Start your work from the fundamental equations on the formula sheet, and derive any additional expressions that you may need.**
- **Circle your answer for each part of each problem.**
- **Clearly mark out any work that you wish the grader to disregard. Do not waste your time erasing.**
- **Your work will be graded based on your ability to write down a logical and organized solution grounded in the correct assessment of the physics of a situation. No credit will be given for an answer that is not justified by a logical solution or where that justification is not organized or readable. Partial credit will be given up to the point where your solution departs from a correct analysis of the physics involved for any given part of a problem.**

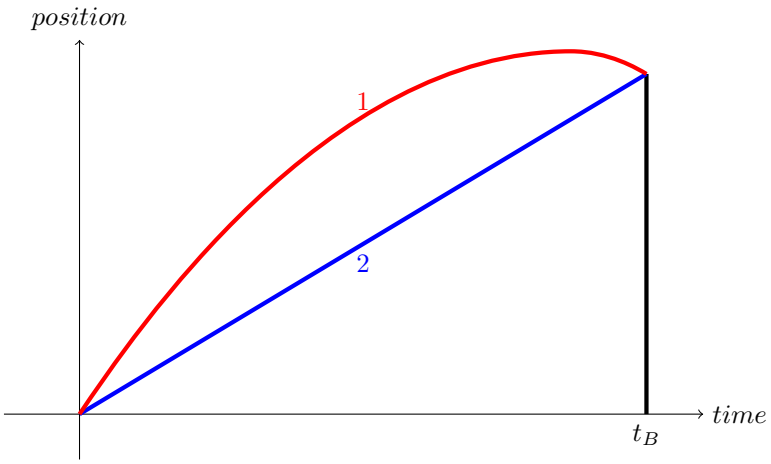
Question	Points	Score
1	5	
2	5	
3	5	
4	20	
5	15	
6	20	
Total:	70	

1. (5 points) You are operating a small remote controlled toy car on the sidewalk along Jamestown Road. As you are standing on the sidewalk, the speed of the toy car relative to you is plotted below. What is the displacement of the toy car between 0 s and 13 s?



- ◯ -20 m
- ◯ 4 m
- ◯ 40 m
- ◯ 80 m
- ◯ 300 m

2. (5 points) The graph below shows position as a function of time for two trains on parallel tracks. Which of the statements is true?



- ◯ Train 1 has a larger displacement than train 2 between time 0 and t_B.
- ◯ At time t_B, both trains have the same velocity.
- ◯ Both trains speed up all the time.
- ◯ Both trains have the same velocity at some time before t_B.
- ◯ Somewhere on the graph, both trains have the same acceleration.

3. (5 points) A ball is thrown straight up, reaches a maximum height, and then falls back downward. Which of the following are true when it reaches its maximum height?

- ◯ Its velocity and its acceleration are zero.
- ◯ Its velocity is zero and its acceleration points upward.
- ◯ Its velocity is zero and its acceleration points downward.
- ◯ Its velocity points downward and its acceleration points upward.
- ◯ Its velocity and its acceleration point downward.

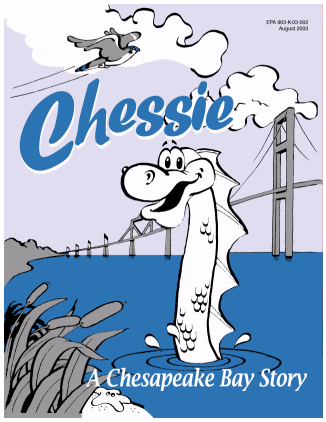
4. A waiter is serving drinks at a seafood restaurant and carrying a tray with a mass $m_1 = 0.500\,\text{kg}$. On top of the tray are a bottle and some glasses with a total mass $m_2 = 2.000\,\text{kg}$. The waiter pushes up from below with a force $\vec{F}$ with a magnitude of $30.0\,\text{N}$. You can approximate the gravitational acceleration as $g \approx 10\,\text{m/s}^2$. You may consider the bottle and glasses as a single object.

(a) (5 points) What is the acceleration (nagnitude and direction) of the entire tray and its contents?

(b) (10 points) What is the force (magnitude and direction) that the tray exerts on the bottle and glasses?

(c) (5 points) What is the force (magnitude and direction) that the bottle and glasses exert on the tray?

5. Chessie is a legendary sea monster said to live in the midst of the Chesapeake Bay. Chessie starts swimming from the Gloucester Point marina and wants to reach Yorktown on the other shore of the York river, directly to the southwest of Gloucester Point. Chessie can swim with a speed of 10.0 knots (or 10.0 nautical miles per hour) relative to the water. However, the tide is coming in from the Chesapeake Bay and there is a current from the southeast to the northwest with a speed of 8.0 knots relative to the ground.



(a) (5 points) In approximately which of the four cardinal directions with respect to the water must Chessie swim to reach Yorktown?

(b) (10 points) The distance between the Gloucester Point marina and Yorktown is exactly 2.0 nautical miles. How long does it take Chessie to reach Yorktown?

6. Physics departments often have a Halloween *pumpkin drop*. In this event, physics students drop pumpkins from the roof of their building with a height of 16.0 m. A student throws a pumpkin with a initial speed of 4.0 m/s at an angle of 60° from the vertical. You can approximate the gravitational acceleration as $g \approx 10\,\mathrm{m/s^2}$.

   (a) (5 points) What is the maximum height above the ground that the pumpkin reaches before it falls to the ground?

   (b) (5 points) What is the vertical component of the initial velocity?

   (c) (5 points) How long does it take for the pumpkin to reach the ground, starting from the time it is released? You may find the following useful: $10^2 = 100$, $11^2 = 121$, $12^2 = 144$, $13^2 = 169$, $14^2 = 196$, $15^2 = 225$, $16^2 = 256$, $17^2 = 289$, $18^2 = 324$, $19^2 = 361$, $20^2 = 400$.

   (d) (5 points) What is the vertical component of the velocity on impact?

Possibly useful relations (feel free to detach this page):

$\vec{v}_{avg} = \Delta\vec{x}/\Delta t$
$\vec{a}_{avg} = \Delta\vec{v}/\Delta t$
$x = x_0 + v_0 t + \frac{1}{2}at^2$
$v = v_0 + at$
$v^2 = v_0^2 + 2a(x - x_0)$
$v_{avg} = \frac{v_0+v}{2}$
$R = \frac{v_0^2}{g}\sin 2\theta$
$h = \frac{v_0^2}{2g}\sin^2\theta$
$\vec{F}_{net} = m\vec{a}$
$\vec{F}_{BA} = -\vec{F}_{AB}$
$\vec{W} = m\vec{g}$
$\vec{g} = 9.80\, m/s^2$ downward
$\cos\theta =$ adjacent/hypotenuse
$x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$
$\sin\theta =$ opposite/hypotenuse
$\tan\theta = \sin\theta/\cos\theta$
$\sin 30^\circ = \cos 60^\circ = \frac{1}{2}$
$\tan 45^\circ = 1$
$\cos 30^\circ = \sin 60^\circ = \frac{\sqrt{3}}{2}$