

As with the first exam, you should be able to complete the exam in 75 minutes. However, if you need more time, you are free to stay after class if you'd like. If you anticipate needing more time and cannot stay (due to other classes or conflicts), let me know and perhaps we can work something out (e.g., you can start the exam earlier).

Please email me if you have questions about the exam.

### Section A

When working on these, do not spend too much time on each one. A minute or two should be sufficient. You need to leave some time for section B. Remember that you can select two choices if you'd like (and receive half-credit if one of them is correct).

1. d (both objects are traveling at a constant speed and direction)
2. a
3. b (the acceleration is in the same direction as the velocity; it doesn't matter that the acceleration is decreasing, it is still speeding up – just less so)
4. d (at that moment, the object's velocity is zero but it will not stay at zero)
5. d (for slowing down, the acceleration is opposite the velocity)
6. e (constant speed and direction)
7. a (we typically don't accelerate at rates larger than free fall; you can also estimate the change in velocity, typically from zero to approximately 30 m/s, and the time it takes to accelerate, typically about 10 seconds)
8. a (the only force acting is the weight and it doesn't change during the flight)
9. e
10. d (the initial velocity does not need to be zero)
11. c (a non-zero net force would result in an acceleration)

12. b

## Section B

1. Over short periods, falling objects, like a stone, fall a distance  $\Delta s$  such that

$$\Delta s = (4.9 \text{ m/s}^2)(\Delta t)^2.$$

Plug in 10 m for  $\Delta s$  and solve for  $\Delta t$  to get a time of 1.43 s.

2. There are several ways to do this. The simplest is to apply the definition of average acceleration

$$a_{\text{avg}} = \frac{\Delta v}{\Delta t}.$$

To do this, you must estimate the change in velocity. In other words, you need to find the initial and final velocities. Since velocity is defined as

$$v_{\text{avg}} = \frac{\Delta s}{\Delta t}$$

and the graph is of  $s$  vs.  $t$ , the average slope between any two points on the graph will give the average velocity during the time interval between the two points.

The slope at the beginning is about 3 m/s (obtained from simply estimating the slope between 0 and 1 seconds). The slope at the end is about  $-3$  m/s (again from simply estimating the slope between 9 and 10 seconds). This means the initial and final velocities are 3 m/s and  $-3$  m/s, respectively, for a difference of  $-6$  m/s. Notice that the difference is NOT zero. Subtracting the initial (3 m/s) from the final ( $-3$  m/s) gives  $-6$  m/s.

To find the average acceleration, then, divide by the time interval (10 s) to get an average acceleration of  $-0.6$  m/s<sup>2</sup>.

3. You can do this two ways. One way is to use the expression to solve for  $v$  when  $t = 1$  s and when  $t = 3$  s. The change in velocity is the difference (0.8 m/s). You can then use the definition of  $a_{\text{avg}}$  ( $\Delta v/\Delta t$ ) and divide by the elapsed time (2 s) to get an acceleration of 0.4 m/s<sup>2</sup>. The other way is to do this algebraically first then plug in numbers. Either way, you will get the same answer.