Physics 111
Exam 1 Solutions

1. How many minutes will it take light, traveling at 186,000 mi/s, to reach us from the sun? The sun is 93 million miles from Earth.

$$t = \frac{d}{v} = \frac{93 \times 10^6 \text{mi}}{1.86 \times 10^5 \text{mi/s}} = 500\text{s} = 8.33\text{min}.$$

2. A race car circles 10 times around an 8 km track in 20 minutes.
(a.) What was the average speed (in m/s) per lap?

$$v_{\text{av}} = \frac{d}{t} = \frac{10 \times 8000\text{m}}{20\text{min} \times 60\text{s/min}} = 66.7\text{m/s}.$$

(b.) What is the average velocity (in m/s) per lap?
The average velocity is defined in terms of the displacement which is zero in this case so the average velocity is also zero.

3. A boat can move at 30 km/hr in still water.
(a.) How long will it take to move 12 km upstream in a river flowing at 6 km/hr?
The velocity upstream will be $v = 30 - 6$ km/hr. The time to make this trip is then

$$t = \frac{d}{v} = \frac{12\text{km}}{24\text{km/hr}} = 0.5\text{hours}.$$

(b.) How long will it take to move 12 km downstream in a river flowing at 6 km/hr?
The velocity upstream will be $v = 30 + 6$ km/hr. The time to make this trip is then

$$t = \frac{d}{v} = \frac{12\text{km}}{36\text{km/hr}} = 0.33\text{hours}.$$

(c.) How does this total trip time compare to the time the trip would take in still water?
In still water the trip of 24 km will take 0.80 hours. This time is less than the sum of the above two trips (0.83 hours).

4. A jet fighter plane is launched from a catapult on an aircraft carrier. It reaches a speed of 42 m/s at the end of the catapult, and this requires 2 s. Assuming the acceleration is constant, what is the length of the catapult?
Can use $v^2 = v_0^2 + 2a\Delta x$ here. $v_0 = 0$ and the acceleration can be found from the given initial and final velocities. Have $a = 42$ m/s so that $\Delta x = 42$ m.

5. A pilot drops a bomb from a plane flying horizontally. When the bomb strikes the ground, what is the horizontal location of the plane (with respect to the bomb)? Explain your answer.
Both the bomb and the plane have the same horizontal velocity and so they will travel the same horizontal distance per unit time. This means that the plane will be directly above the bomb when it hits the ground.

6. (a.) Draw a position versus time graph for an object traveling at constant speed that starts from x = 2 m.
A straight line wit h positive slope starting at the point (0,2).

(b.) Draw a position versus time graph for an object located at x = 2 m and is at rest for 2 seconds and then moves with negative velocity.
A horizonatl line from the point (0,2) to (2,2). From here the line will have a constant negative slope.

(c.) Draw a velocity versus time graph for an object that is initially at rest and then travels at constant velocity.
A horizontal line starting from the origin that jumps up to another horizontal line.

(d.) What does the area under a velocity versus time graph represent?
The area measures the total distance traveled.

7. A girl throws a stone straight down from a bridge. The stone leaves her hand with a velocity of 8.00 m/s at a height of 12 m above the water below. How much time does it take for the stone to hot the water?
The equation the describes the change in height of the stone is

$$\Delta y = \frac{1}{2}gt^2 + v_{0y}t.$$

The positive y direction is taken as the direction of motion and the initial height if the stone is taken as 12 m (the height of release). Plugging in these values results in having to solve the following equation for t

$$4.9t^2 + 8t - 12 = 0.$$

The roots of this equation are 0.95 s and -2.58 s. The negative root can be rejected.

8. A submarine must travel how fast (with respect to the water) and be pointed in what direction such that it moves 10 m/s directly northward (relative to the earth) if the water moves to the west at 5 m/s?
The question gives the legs of a right triangle so to find the third side (the hypotenuse) requires applying the Pythagorean Theorem. This yields 11.2 m/s for the speed of the submarine. The direction is then given by

$$\theta = \tan^{-1}\frac{10}{20} = 26.6^\circ$$

east of north.

9. A hunter points a rifle horizontally 3.3 m above the ground. The bullet leaves the barrel at 325 m/s.
(a.) How long does it take the bullet to reach the ground?
An object fired horizontally will take a time

$$t = \sqrt{\frac{2\Delta y}{g}}$$

to descend a total change in height Δy. This yields 0.808 s.

(b.) If instead of being fired the bullet is dropped from rest 3.3 m above the ground, how long does it take to reach the ground?
The answer is the same as in part a. This is because the only acceleration acting on the bullet (once it leaves the barrel of the gun) is that due to gravity.

10. A cannonball is dropped from the crow?s nest of a pirate ship. The crow's nest is at a height of 10 m above the deck of the ship and the ship is moving 10 m/s parallel to the shore of an island. How far (horizontally) will the cannonball travel as seen by (a.) an observer on the deck and (b.) an observer on the shore?
The observer on the ship will see the cannonball fall straight down as they (the observer, the ship, and the cannonball) are all moving with the same velocity. The observer on shore will see the cannonball travel a distance $x = vt$ where t is the amount of time it takes the cannonball to fall from a height of 10 m (1.43 s) and v is the speed of the ship. Here $x = 14.3$ m.