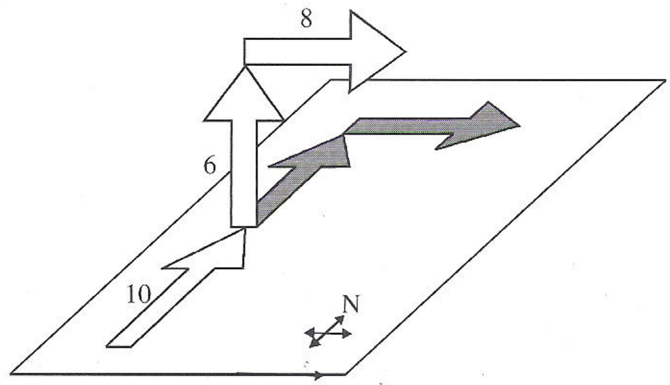
HOMEWORK 1 SOLUTIONS

1. **C is correct.** The balloon travels in three perpendicular directions. These can be considered three displacement vectors. The total displacement is the vector sum of the three. If you notice, two of the vectors have lengths of 8 and 6, multiples of 4 and 3 respectively. These are the components of a 3-4-5 triangle. Thus, the displacement from the tail of the 6 km vector to the head of the 8 km vector is 10 kilometers. This 10 km vector is perpendicular to the other 10 km vector. Using the Pythagorean theorem on the two 10 km vectors gives a total displacement of approximately 14 km.



$$\sqrt{6^2 + 10^2 + 8^2} = \text{net displacement}$$

2. **A is correct.** Since the runner is on a circular track of ? km, the runner will end up where he/she began. This is zero displacement and zero velocity.

3. **B is correct.** The man is making a 30-60-90 triangle. Where he turns represents the 30° angle in the triangle. The distance back to the entrance is half the hypotenuse or 100 sin30°. You can either recognize the proportions of a 30-60-90 triangle or, if you have a lot of extra time on your hands while taking the MCAT, use the law of cosines: $A^2 = B^2 + C^2 - 2BC\cos(a)$.

4. **D is correct.** Acceleration is the rate of change of velocity. Since velocity is a vector it specifies direction. The direction of the earth's motion is constantly changing.

5. **C is correct.** Since the beginning and starting points are the same, the displacement is the same.

6. **C is correct.** If the car is slowing down, the velocity and acceleration must have opposite signs. Since the car is moving forward, it's safe to assume that the velocity is positive.

7. **B is correct.** The direction for a vector must specify a straight line at a specific point. You couldn't draw an arrow to represent "in a circle."

8. **C is correct.** You need to convert your units.

$$\left(\frac{36\text{ km}}{1\text{ hr}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ hr}}{3600\text{ sec}}\right) = 10\text{ m / s}$$

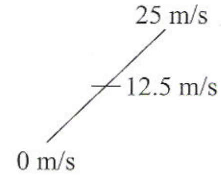
In 10 seconds, the elephant can run 100 m.

9. **C is correct.** Velocity is the slope on a d/t graph. Constant velocity requires only a straight line on a d/t graph. Any acceleration represents a change in velocity and so can not represent constant velocity.

10. **C is correct.** Since we are looking for distance and not displacement, we add up the total area between the line and the x-axis. We could also use our linear motion equations since there is constant acceleration.

11. **B is correct.** The graph shows an object moving in one direction at a constant velocity and suddenly changing directions. There is no gradual acceleration. The baseball is the only object that suddenly changes direction. A is wrong because the description describes gradual acceleration, and there is no gradual acceleration in the graph. C is constantly changing velocity. D is a gradual change in velocity.

12. **B is correct**. This problem may be tricky because the question only implies a necessary variable. That variable is initial velocity. The initial velocity is zero. The average velocity of any constantly accelerating object that starts with zero velocity is the final velocity divided by two. This from $v_{avg} = (v + v_o)/2$. Then the average velocity times time equals displacement, $v_{avg}t = x$. Thus, 25/12.5 = 2. Or, by Salty's method:



Average velocity times time equals distance: 12.5 × 2 = 25.

13. **A is correct**. This is a plug and chug problem. The correct formula is $v = v_o$ + at. Which results in 25 = 50 + a2. Thus a = 12.5. You also could reason that if it had taken only one second to slow from 50 to 25 m/s then the acceleration would have been –25 m/s^2. But it took more than one second so the acceleration must be less.

14. **A is correct.** The graph clearly shows that displacement increases with time. Since the displacement graph is a straight line, the particle must be moving at constant velocity, so neither velocity nor acceleration are increasing.

15. **C is correct.** Acceleration is 5 m/s^2 so the velocity is reduced by 5 m/s each second. Starting from 20 requires 4 seconds. Average velocity is between 20 and 0 which is 10 m/s. 10 m/s for 4 seconds gives 40 meters. Or use the equation that doesn't include time.

$$v_f^2 = v_o^2 + 2ax$$

The car comes to a stop, so $v_f = 0$. If we plug in $v_o = 20$ and $a = -5$, we'll get $x = 40$ m.

16. **D is correct.** In order for the particle to move backwards, the velocity graph would have to dip below zero. Between 10 and 15 seconds, the particle is slowing down, but not going backwards.

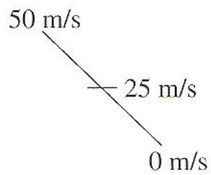
17. **C is correct**. The best way to answer this question is to plug 4 seconds into the linear motion equations $s = s_o + v_o t + \frac{1}{2}at^2$. This results in $s = \frac{1}{2}at^2$. The distance traveled by the apple is 80 m so it reaches 20 m in altitude. You could solve this problem using proportions. The square of the time is proportional to the distance. If we double the time, we multiply the distance by 4.

18. **D is correct**. Since both the ball and the skydivers are accelerating at the same rate, each skydiver should aim for the other's chest.

19. **A is correct**. You should use Salty's system in every single physics problem. However, sometimes the problem is easy enough for you to imagine the diagram in your head. This problem probably requires actually drawing a diagram. Once you have your diagram, you may notice that the antelope needs to be in the air for 2 seconds at 10 m/s to clear 20 meters. So now you have t. You know that the upward trip equals the downward trip, so the downward trip lasts one second. You also know that the downward trip starts at zero because a projectile at its peak has zero velocity. The question is now simplified to "How far does a free falling body starting from rest travel in one second". At the end of one second the body is traveling at 10 m/s, thus its average velocity is 5 m/s. The object travels 5 meters. Alternatively, once you have 2 seconds, you can plug 2 seconds into $s = s_o + v_o t + \frac{1}{2}at^2$, with s and s_o as zero. Doing the math gives you the initial velocity of 10 m/s. The velocity at the top is zero. Using $v^2 = v_o^2 + 2ax$ gives you $x = 5$.

20. **A is correct**. This is a proportions question. The correct equation is $v_o \sin\theta =$ □$(2gh)$. Remember, due to the symmetry of projectile motion, the velocity in this equation can be initial or final depending upon the direction of motion. Multiplying the height by four only doubles the velocity.

21. **B is correct**. You can use $v_o\sin\theta =$ □$(2gh)$. The sine of 30° is ½. Thus the vertical velocity is 50 m/s. 50^2 is 2500. Divide this by $g = 10$, and by 2 gives 125. Practice doing problems like this in your head to save time, build your confidence, and most of all, to sharpen your skills. The initial vertical velocity is 50 m/s; the final at max height is zero. This is a change in velocity of 50 which takes 5 seconds at 10 m/s^2. Draw your line and multiply the average velocity by 5 seconds.



22. **B is correct.** At terminal velocity, acceleration is zero. The force of air resistance counters gravity exactly so the force is equal to the weight for both balls. Ball X requires more collisions with air molecules to compensate for the larger force of gravity. More collisions means greater air resistance.

23. **A is correct.** The horizontal speed has no effect on the length of time that a projectile is in the air, so you don't need it here. Because the initial vertical speed is zero, you can use the equation below.

$$x = (1/2)gt^2 \text{ with } x = 40 \text{ and } g = 10$$

$$t = \sqrt{8} = 2.8$$

Since there is only one significant figure in the numbers in the problem we round the answer up to 3.

24. **B is correct.** The horizontal distance traveled for a projectile is given by $vt\cos\theta$. In this case, $v = 30$, $t = 6$, and $\theta = 40°$.