PHYS 211 Exam 1 - Practice Test Solutions

1A
The pattern or structure of the graph is what we should be looking at.

Based on the graph for acceleration, we can see that for the first 3 secs we have a constant negative acceleration (-2 m/s^2). This should equate to a negative or downward slope for velocity during the first 3 secs. Only answers (a) and (b) show this.

From t = 3 to t = 6, the acceleration becomes positive (+1 m/s^2), and so we expect a positive or upward slope, which again is present in both (a) and (b). However, since the magnitude of the accelerations is larger for the first three seconds we should expect to see a steeper slope from t = 0 to t = 3 than from t = 3 to t = 6. This only happens in graph (a).

2B
Remember people, the formula for acceleration is:

$$\text{Average Acceleration, } \bar{a} = \frac{\Delta v}{\Delta t}$$

However, we can't just plug in the velocities given since they're not all in the same dimension. The easiest way is to use the vector coordinates for both velocities:

V(initial) = (0i + 4.0j) m/s,   V(final) = (3.0i + 0j)

ΔV = V(final) - V(initial) = (3.0i – 0i) + (0j – 4.0j) = (3.0i – 4.0j) m/s
The next step is to write that vector in terms of its magnitude, using Pythagorean Theory to get ΔV = 5 m/s.

Finally, we plug into the equation for acceleration:

$$a = \frac{5m/s}{2s} = 2.5\,m/s^2$$

3E
The area under the graph, the integral, from t=0 to t=3, will give us the displacement. The area equals 7m, so the final position at t=3 is 12m, since the particle was originally at x=5m.

4D
Here the definition for average speed is total distance / total time. The information given has everything we need except the distance travelled during the first portion of the trip, so we must calculate that first:

$\Delta x_1 = v_1 t_1$ = (80km/hr)(1/2hr) = 40km

So we get average speed = [40 + 0 + 120] / [1/2 + 1/6 + 2] = 60

5C
There are two parts to this problem, the first requires figuring out the displacement and speed the cheetah reaches after the first 1.5s:

<u>x-axis</u>

V_0 = 0 m/s
V = ?
a = 15 m/s^2
t = 1.5 s
Δx = ?

3 out of 5 is enough and so we can solve for both using:

$$\Delta x = v_0 t + \tfrac{1}{2} a t^2 = 16.875 m$$
$$v = v_0 + at = 22.5 m/s$$

Since we need to know how long it will take to reach 60m, we must now determine how much farther the cheetah needs to travel: 60 – 16.875 = 43.125 m at 22.5 m/s.
The speed is constant, so the time required is:
t = 43.125m / 22.5m/s = 1.9s

Thus the total time taken to reach 60m equals = 1.5s + 1.9s = 3.4s

6B

This is essentially a question dealing with 2-dimensional motion where both dimensions (x-axis and y-axis) have their own constant acceleration.

We are concerned with finding the y-coordinate, which is like solving for Δy. The only problem is we are only given initial velocity and acceleration for the y-axis (2 variables are not enough). Remember, when dealing with 2-D motion, you can always use the same time found in the other axis, in this case we can use the time for motion along the x-axis. All we need to do is find out what that time is:

<u>x-axis</u>

V_0 = 0 m/s
V =
a = 6.0 m/s^2
t = ?
Δx = 27 m

3 out of 5 is enough and so we can solve for time using:

$$\Delta x = v_0 t + \tfrac{1}{2} a t^2$$

This gives us t = 3.0 s, which we can use for calculations involving the y-axis:

<u>y-axis</u>

V_0 = 4.0 m/s
V =
a = 4.0 m/s^2
t = 3.0 s
Δy = ?

Again we use:

$$\Delta y = v_0 t + \tfrac{1}{2} a t^2$$

To get Δy = 30 m

7C

The velocity as the ball leaves the table is completely horizontal, so we should first look to the x-axis to calculate the value:

$V_x = \Delta x/t = 1.52/t$

Since we don't know the time, we must use the y-axis to get that information:

<u>y-axis</u>

$V_0 = 0$ m/s
V =
a = -9.8 m/s^2
t = ?
$\Delta y = -1.5$m

Again we use:

$$\Delta y = v_0 t + \tfrac{1}{2}at^2 = \tfrac{1}{2}at^2$$

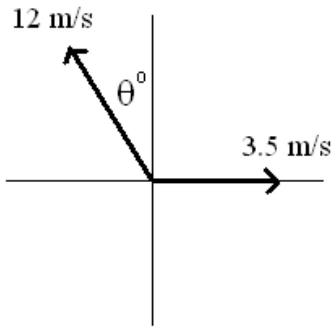
$$t = \sqrt{\frac{2\Delta y}{a}} = 0.55s$$

Now we have time, we can plug it back into the x-axis equation to get velocity:

$V_x = \Delta x/t = 1.52/0.55 = 2.76$ m/s

8B

The only way to travel due north is to counter the vector pointing east with a vector that has an x-component pointing west, as shown below:



Specifically, we must ensure that x-component of the 12 m/s vector is equal to 3.5 m/s, so that the only net vector is the y-component of the 12 m/s which points north.

So we get:

$12\sin\theta = 3.5$

$\theta = \sin^{-1}\left(\frac{3.5}{12}\right) = 17^{\circ}$

Which gets us 17° west of north.

9D

A typical 2-D question where we're asked to determine Δy but don't have enough variables to do so. So, as usual, when dealing with projectile motion we can use the time from the other dimension, x-axis, to help us out.

x-axis

$$V_x = \frac{\Delta x}{t},$$

so

$$t = \frac{\Delta x}{V_x} = \frac{12}{21\cos 25°} = 0.631s$$

Now we can go to the y-axis and solve for Δy:

y-axis

V_0 = 21sin25° = 8.87 m/s
V =
a = -9.8 m/s^2
t = 0.631 s
Δy = ?

We then use:

$$\Delta y = v_0 t + \tfrac{1}{2} a t^2 = 3.65 \text{ m}$$

10C

Remember that whenever you're asked to solve for final speed/velocity in any projectile motion problem, you must consider both the x-and y- components of the vector.

So for this particular question, we can start with either the x- or y-axis.

For the x-axis, the final velocity is the same as initial velocity since there's no acceleration along the horizontal axis.

Therefore $V_x = V\cos\theta = 28\cos 55° = 16.06$ m/s

For the y-axis:

<u>y-axis</u>

$V_0 = 28\sin 55° = 22.9$ m/s

$V = ?$

$a = -9.8\ m/s^2$

$t = 3$ s

$\Delta y =$

And we can use the following to solve for V_y :

$$V_y = V_0 + at = -6.46 \text{ m/s}$$

Lastly, we solve for the resultant vector of the two velocity components using Pythagorean theory to get V = 17.3 m/s.

11C
Despite how morbid this question might be, the physics behind it is quite straightforward. The scenario suggests a 1-D motion type-problem where we're solving for time and ae given the following data:

<u>y-axis</u>

V_0 = +8 m/s
V =
a = -9.8 m/s^2
t = ?
Δy = - 420 m

The only problem is that to solve for t we would have to set up a quadratic eqn; which is time consuming, unless you plot the function on your graphing calculator and see where it crosses the x-axis.

Alternatively, we can first solve for V and then solving for time will be far easier.

So we use:

$$v^2 = {v_0}^2 + 2a\Delta x$$

And get V = -91.08 (remember that it's negative because the man is falling down, not up)

Now we can use any equation to solve for time:

$$v = v_0 + at$$
$$t = \frac{v - v_0}{a} = \frac{-91.08 - 8}{-9.8} = 10.11s$$

12B

Since the two balls have different initial speeds, but the same constant acceleration due to gravity, the easiest way to solve this problem is to create position functions for each of the balls and use them to solve for time.

$$(1)\Delta y_1 = 15t + \tfrac{1}{2}at^2$$
$$(2)\Delta y_2 = -10t + \tfrac{1}{2}at^2$$

The question asks for when the two balls will be 50m apart, so that means we want:

$$\Delta y_1 - \Delta y_2 = 50$$

Which can be re-written as:

$$(15t + \tfrac{1}{2}at^2) - (-10t + \tfrac{1}{2}at^2) = 50$$
$$25t = 50$$
$$t = 2s$$

13B

This is a particularly difficult question to deal with especially when you consider that you are not even given the height of the building. With only the initial velocities of the two stones, this question would be impossible to solve except that in this particular case the two velocities have equal magnitude. Why is that important?.....We'll get to that in a minute. First, we must recognize a rule about projectile motion that states that an object thrown up with any initial velocity, V, will be traveling at a velocity of negative V when it falls back down to the height that it was initially thrown from. In other words, or to give an example relative to this question, the stone that is thrown upwards at 15 m/s will reach its max height and then start falling back down towards earth with increasing negative velocity…and when it gets to the position from which it was released (the start point of this question) it will be traveling at -15 m/s.

So why is this information helpful?...Well it tells us that the stone thrown upwards will eventually return to its starting point after some amount of time, and that at that exact time it will the same velocity that the other stone had when it was initially released (-15 m/s)….which means that it will follow the exact same path as that stone and will take the exact same amount of time to reach the ground as that stone did when it was initially released.

And so to find out how much time will pass between the two stones hitting the ground, we only have to calculate how much time the stone thrown upwards spends in the air before returning to its initial release point. For this scenario we have the following:

y-axis

$V_0 = 15$ m/s
$V = -15$
$a = -9.8$ m/s^2
$t = ?$
$\Delta y = 0$

Yes..we even have 4 variables as a reward for understanding physics.

And we can use any equation to solve for time:

$$v = v_0 + at$$

$$t = \frac{v - v_0}{a} = \frac{-15 - 15}{-9.8} = 3.06s$$

14D
This question asks for the speed and represents 2-D motion. However, the equations for position in both axis are given, so we cannot rely on the typical equations for motion that we have used up to this point. The easiest solution is take the derivative of each position function to get velocity for each axis and then to calculate the specific velocities at t = 2s:

$$\frac{d}{dt}x(t) = v_x(t) = 4, \quad \frac{d}{dt}y(t) = v_y(t) = 6t - 9,$$
$$v_x(2) = 4m/s \qquad v_y(2) = 3m/s$$

Thus the resultant vector velocity (speed) is: $\sqrt{4^2 + 3^2} = 5m/s$

15B
The y-axis is the best approach to analyzing the variables since it is due to the acceleration of gravity along the y-axis that the ball drops back down:

So we get:

<u>y-axis</u>

$V_0 = v_0\sin\theta$
V =
a = -g
t = ?
$\Delta y = 0$

We then use the below equation which we can simplify to solve for time:

$$\Delta y = v_0 t + \tfrac{1}{2}at^2$$
$$0 = (v_0\sin\theta)t + \tfrac{1}{2}(-g)t^2$$
$$\tfrac{1}{2}gt^2 = (v_0\sin\theta)t$$
$$\frac{gt}{2} = v_0\sin\theta$$
$$t = 2v_0\sin\theta/g$$

16C

The easiest approach will be to create position functions for each ball. First though, we must consider that the balls collide at some point between 0 and 50 m, called y.

That means that for ball A its displacement will be $\Delta y_A = y - 0 = y$
And then for ball B its displacement will be $\Delta y_B = y - 50$

Now that we've clarified how the two displacements relate to the point of collision, y, we can go ahead and write our position functions:

$$(1)\Delta y_A = y = V_0 t + \tfrac{1}{2}at^2$$
$$(2)\Delta y_B = y - 50 = 0t + \tfrac{1}{2}at^2$$

If we then solve eqn (2) in terms of y, and set it equal to y in eqn (1) we get:

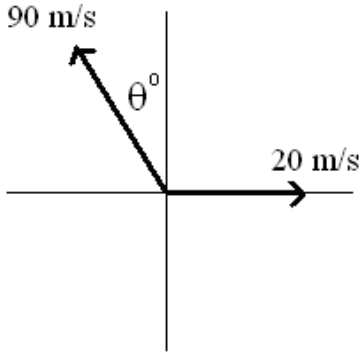
$$y - 50 = 0t + \tfrac{1}{2}at^2$$
$$y = \tfrac{1}{2}at^2 + 50$$
$$y = \tfrac{1}{2}at^2 + 50 = V_0 t + \tfrac{1}{2}at^2$$
$$50 = V_0 t$$

Thus when we plug in t = 2.5 s we get:

$$V_0 = \frac{50}{2.5} = 20\, m/s$$

17B

The appropriate vector diagram should look as follows:



To counter the easterly wind, the plane's velocity vector must have an x-component that is equal to 20 m/s. So we get:

$$90\sin\theta = 20$$

$$\theta = \sin^{-1}\left(\frac{20}{90}\right) = 12.84^{\circ}$$

Now that we have the angle we can calculate the velocity component that heads due north using V = 90cos12.84° = 87.7 m/s

Finally we use the equation for average velocity:

$$V = \frac{\Delta x}{t},$$

$$t = \frac{\Delta x}{V} = \frac{350000}{87.7} = 3988.6s = 66.5\,\text{min}$$