Solutions – Practice Test – PHYS 211 Exam 2

1A
We can split this problem up into two parts, each one dealing with a separate axis.

For both the x- and y- axes, we have two forces (one given, one unknown) and we get the following equations:

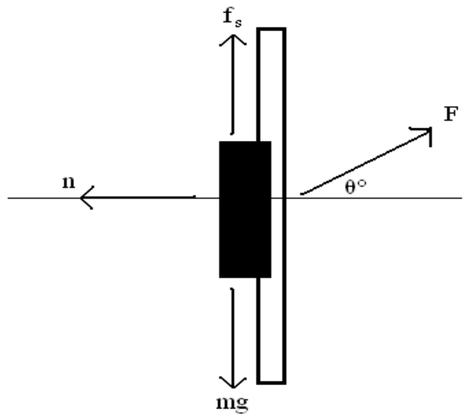
$$F_x = -2.5 + x = ma_x$$
$$F_x = -2.5 + x = (1.7)(3.1)$$
$$x = 7.77N$$

$$F_y = 1.4 + y = ma_y$$
$$F_y = 1.4 + y = (1.7)(-2.5)$$
$$y = -5.65N$$

Since we now have the x and y components of the force, we use Pythagorean equation to get F = 9.61N

2A

A somewhat confusing problem without the correct free-body diagram, shown below:



As always, it's best to put all your force vectors into their x- and y-components (if they aren't already) so we should break apart the applied force, F, into its y-component, Fsinθ, and its x-component, Fcosθ.

Now, and here's the important part, since the book isn't sliding down (or moving anywhere really) there's no net force acting on it in either axis/dimension. This basically means that the sum of all the forces pointing up must equal the sum of all those pointing down. And also that the sum of all the forces pointing left equals the sum of those pointing right.

From that we get the following two equations:

$$(1) f_s + F\sin\theta = mg$$

$$(2) n = F\cos\theta$$

The first equation can be re-written to show how friction can be broken down into its constituent parts, and after we substitute n from the second equation, we can then solve for F:

$$f_s + F\sin\theta = mg$$

$$\mu_s n + F\sin\theta = mg$$

$$\mu_s F\cos\theta + F\sin\theta = mg$$

$$F(\mu_s\cos\theta + \sin\theta) = mg$$

$$F = \frac{mg}{\mu_s\cos\theta + \sin\theta} = 5.3N$$

3D

The 100N force will be applied to the system (which has total mass 10kg) causing it to accelerate with $a = F/m = 100/10 = 10\ m/s^2$.

Thus we know that the 6kg mass will be accelerating at $10\ m/s^2$, and so the force acting on it must be given by $F = ma = (6)(10) = 60N$

4E

All of the statements could be true:

i. If the elevator were accelerating in either direction the normal force would not be equal to the man's weight, however since they don't mention acceleration we must assume the acceleration is zero, and the upward velocity is constant.

ii. The acceleration would have to be in the upward direction for normal force to be greater, which would mean that although the elevator is moving downward it is slowing down due to an upward acceleration.

iii. This is always true when accelerating downward.

5B

Since the crate is at rest, we would need to overcome the force of static friction in order to get it moving. The maximum force of static friction is given by

$$f_s = \mu_s N = (0.5)(40) = 20N$$

Thus, it is clear that the 12N force applied will not be great enough to overcome static friction and the block will not move. In fact, the force of static friction will simply match the applied force of 12N, ensuring that the object remains still.

6C

Looking at the pulley system, we can generate the equation for the entire system that says the net force acting on the pulley system is:

$$F_{Net} = m_3 g = (m_3 + m_9)a$$
$$a = 2.45\ m/s^2$$

Now we have acceleration we can set up the equation for net force on either object to solve for tension. For the 3kg mass the equation becomes:

$$F_3 = m_3 g - T = ma$$
$$T = 22.05N$$

7A

This is actually a rather tricky question. Given the information provided we cannot actually calculate the average frictional force, however we do know that since the bear is able to pick up speed during its descent, the weight must be greater than the force of friction. The weight of the bear is mg = 245N, so the average frictional force must be less than 245N, and only one answer obeys that rule.

8E

It's important for questions like this not to get too bogged down on the details of the problem. This question is similar to that of the man in the elevator accelerating down, except this time we've replaced normal force with tension.

The ball's speed is increasing in the downward direction, so it must be accelerating downwards. We can calculate the acceleration easily using:

$$a = \Delta V/\Delta t = [(-4) - (-2)]/2 = -1\ m/s^2$$

As always we can set the net force equal to mass x acceleration and then solve for tension. Since the weight vector points down and the tension points upwards, the weight must be larger as we are accelerating down, and we get:

$$F = -mg + T = ma$$
$$T = 4400N$$

9E

As discussed at the review, we want to rotate the free-body diagram for scenarios like this to minimize the amount of algebra required. In doing so, the normal force now points along the +y-axis, while friction goes along the x-axis (up the incline) and only the weight vector is now not aligned with either axis. As such, the weight vector (mg) is broken into its x- and y- components, with mgcos40° directly opposing the normal force, and mgsin40° directly opposing friction (down the incline). Since there is no net force along the y-axis we solve for normal force, n = mgcos40, and plug it to the equation below.

The resulting net force along the incline (which is now the x-axis) becomes:

$$F_{Net} = mg\sin\theta - f_k = ma$$
$$F_{Net} = mg\sin\theta - \mu_k n = ma$$
$$F_{Net} = mg\sin\theta - \mu_k mg\cos\theta = ma$$
$$a = 2.92\ m/s^2$$

With acceleration now given, we can use the kinematic equations to solve for final velocity:

$$V^2 = V_0^2 + 2ad$$
$$V = 6.03\ m/s$$

Note that distance, d, is the length of the incline, not the height, so we set up a triangle with the distance being the hypotenuse and the height being opposite the angle, resulting in d = h / sin40 = 6.22 m.

10B

The free-body diagram shows the net force along each axis would be as follows:

$$F_{Net,y} = n - mg = 0$$
$$Thus: n = mg$$

$$F_{Net,x} = ma$$
$$F - f_k = ma$$
$$F - \mu_k n = ma$$
$$F - \mu_k mg = ma$$
$$F = ma + \mu_k mg$$

Since we already have the mass, and the coefficient of friction, all we need to solve for the applied force, F, is the acceleration, a.

Assuming the crate starts from rest, its initial kinetic energy would be zero, thus the final kinetic energy must be equal to 600J. This allows us to solve for the final velocity, v_f, using the following equation:

$$K_{final} = \tfrac{1}{2} m v_f^2$$
$$v_f = \sqrt{\frac{2K_{final}}{m}} = 34.64\ m/s$$

Using the kinematic equations we can now solve for acceleration:

$$v_i = 0$$
$$v_f = 34.64\ m/s$$
$$a = ?$$
$$t =$$
$$\Delta x = 75\ m$$

$$v_f^2 = v_i^2 + 2a\Delta x$$
$$a = 8\ \text{m/s}^2$$

Lastly, we plug in the acceleration into the above equation to solve for applied force, F:

$$F = ma + \mu_k mg = 9.96N$$

11B

Here we're looking for centripetal acceleration, which only requires velocity and radius. We get velocity by converting revolutions per second to meters per second:

$$v = \frac{2(2\pi r)}{t} = \frac{2(2\pi \times 0.5)m}{1s} = 2\pi\, m/s$$

And so we get acceleration:

$$a_c = \frac{v_t^2}{r} = \frac{(2\pi)^2}{0.5} = 8\pi^2\, m/s^2$$

12E

Before we can solve for the drag force at 30 m/s we need to recognize that the drag force at terminal velocity is equal to the weight of the object, mg. Since drag force is proportional to the square of the velocity, and changes the velocity must be squared before we can predict the changes to the drag force.

Let D represent the drag force at terminal velocity (v = 80 m/s), and let D' represent the drag force at 30 m/s.

Since $D \propto v^2$,

$$D' \propto \left(\frac{30}{80}v\right)^2 = \left(\frac{30}{80}\right)^2 v^2 = 0.141v^2$$

Thus:

$$D' = 0.141D = 0.141mg = 27.6N$$

13C

For a question like this we need to take all the forces acting on the object and put them into the x- and y- components, that way we can set up equations for net force along each axis. In this particular question, we are only really interested in the y-axis, since that is where we'll find the normal force:

The force pointing up will be the normal force, n, and the forces pointing down will be the weight, mg, and the vertical component of the 200N force, 200sin20° = 68.4N

Since the y-axis has no net force, the sum of forces pointing up equal the sum of forces pointing down, thus we set up the equation for the y-axis:

$$F_{Net,y} = 0 : n = mg + 200\sin 20^0$$

$$n = 313\ N$$

14A
It is important to understand that vertical scales, such as those shown in the problem, will have a tension force distributed evenly throughout the length of the spring. The result is similar to what we see when any mass is hung from a string or rope, there is a continuous tension force pulling it in both directions. The fact that there are two scales makes no difference compared to if there was only one scale. In both cases, there is continuous tension force equal to the weight of the fish distributed along the springs. Thus each scale will read 16 N.

Note that even if there were 20 scales all in a row, assuming they were all massless (like in this question) then they would all read the same value of 16 N.

15B
According to drag forces, the equation for drag force is proportional to surface area.

Given the volume of each cube we can determine the side lengths of Cube A and Cube B are 3 cm and 4 cm, respectively, meaning their cross-sectional areas are 9 cm^2 and 16 cm^2, respectively.

Since all the other variables are constant for both cubes, the ratio of Drag Force for Cube B to Drag Force for Cube A is D_B / D_A = 16 / 9.