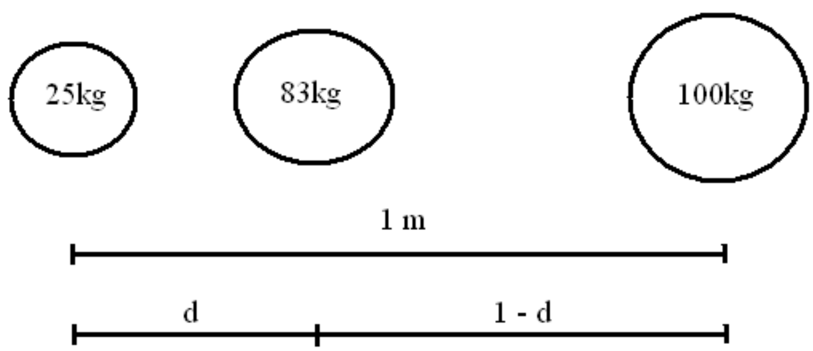
Solutions – Practice Test - PHYS 211 Final Exam (New Material)

1C

The question talks about gravitational forces, and so we need to use our new equation for gravitational force: $F = Gm_1m_2 / r^2$

What we need to realize is that the gravitational forces acting on the 83 kg object must cancel each other out, so the force pulling it towards the 25 kg mass must equal the force pulling it towards the 100 kg mass.



Using the above diagram we can create an equation representing the equal gravitational force:

$$(G)(25)(83) / d^2 = G(100)(83) / (1-d)^2$$

Notice that after simplifying the above equation not only do the G's cancel out but also the 83kg mass.

Finally we solve for d to get:

$$d = 0.33 \text{ m} = 33 \text{ cm}$$

2D

We can calculate acceleration using the equation F = ma, where F is the force of gravity, and m is the mass of any object on the planet's surface. We then expand the equation to get:

$$F = ma$$

$(GMm) / r^2 = ma$, where M is the mass of the planet and r is its radius.

Note that the mass of the object can cancel out and we are left with an equation for acceleration due to gravity:

$$a = GM / r^2$$

If we let the above equation represent the acceleration due to gravity on earth, then for the M-class planet the acceleration would be:

$a = G(2M) / (2r)^2$, which simplifies to:

$$a = GM / 2r^2 = ½(GM / r^2)$$

Looking back at the equation for acceleration on earth we see that without even plugging in any values the acceleration on the M-class planet would be half the acceleration on earth, so we pick g/2.

3C

Remember that the escape speed is given by the equation:

$$v = \sqrt{\frac{2GM}{R}}$$

Given that the planet has double the mass and double the radius, the equation becomes:

$$v = \sqrt{\frac{2G(2M)}{(2R)}}$$

Since the factor of 2 cancels out, we end up with the same expression for escape speed.

4C

This is a straight-up question dealing with conservation of angular momentum. We need to show how initial momentum equals final momentum and then solve for the final angular velocity:

$L_i = L_f$

$I_i\omega_i = I_f\omega_f$

$(0.02)(3) = (0.02 + mr^2)\ \omega_f$

where mr^2 represents the added inertia caused by the bird and equals $(1)\ (0.1)^2 = 0.01$

Plugging that in allows us to solve for final angular velocity, which is 2.0 rad/s

5D

This problem requires the use of conservation of energy, where we use the new version of potential energy since the problem does not want us to take into account earth's gravity, or any other forces except for their own gravitational attraction. So we can write:

$U_i = U_f + K_f$ where we don't include K_i since the particle started at rest.

This then expands to become:

$(-GMm / 3) = (-GMm / 2) + (\frac{1}{2}mv^2)$

Notice that the distance is initially 3 m since we need the distance between the centers of mass, which must include the planets radius.

After the m's cancel out we can simplify and solve for v to get:

$$a\sqrt{\frac{GM}{3}}$$

6B

The question is referring specifically to comparing rotational kinetic energies, since the girl is spinning. In order to compare kinetic energies we must first have not only the different angular speeds, but also the different inertias. To figure that out, we will first have to use conservation of angular momentum $I_i\omega_i = I_f\omega_f$, which breaks down to:

$I_i\omega_i = I_f\omega_f$

$I_i\omega_i = I_f(2\omega_i)$ and after the ω_i's cancel out we have

$I_i = 2I_f$

Now we plug in these variables into the ratio of final kinetic energy to initial kinetic energy:

$$\frac{K_f}{K_i} = \frac{\frac{1}{2} I_f \omega^2}{\frac{1}{2} I_i \omega_i^2} = \frac{I_f (2\omega_i)^2}{(2I_f)\omega_i^2} = \frac{4}{2}$$

Thus the ratio is 2:1

7C

For this we imagine a number line with the girl at the origin (since the question asks for distance relative to her) at the boy at a distance of 10 m.

To calculate center of mass: $\frac{(40 \times 0) + (60 \times 10)}{100} = 6$

So we conclude that the center of mass is 6 m from the origin, or 6 m from the girl.

8C

Power, P is Work/Time. In this question the dog does work by lifting his own weight up the height of the stairs.

So we get: $P = \frac{W}{t} = \frac{mg(15 \times 0.25)}{11} = 83.5W$

9B

When each child throws the ball he/she gives the ball momentum, $p = (0.35)(4.5) = 1.575$ kg m/s

Since momentum must be conserved, the child also gets 1.575 kg m/s of momentum, just in the other direction.

Furthermore, after catching the ball, the child picks up another 1.575 kg m/s of momentum.

This means in total each child gets 3.15 kg m/s of momentum.

From this we can calculate the velocity, $v = \Delta p/m = 0.063$ m/s, where the mass is 490/9.8

10D

The formula for calculating inertia for a hollow sphere (or shell) is $1/3mr^2$, however it technically doesn't matter since both objects are the same type of shape. In fact all we have to realize is that no matter what shape we're dealing with: **inertia is proportional to the square of the radius**, which means that if the radius increases by a certain factor we must square that factor to find out how much the inertia increases by. Thus, in this case, tripling the radius would increase the inertia by a factor of $(3)^2 = 9$ times the original inertia. So we pick 9I.

11A

The rule for any question like this is that the object with the larger inertia will have the smaller velocity, (angular or linear). Thus, the hollow cylinder will have the smaller linear velocity.

12D

To get the acceleration of the object we should look at the net force acting on it and set it equal to mass x acceleration….so we get:

$mg - T = ma$, where T is the tension in the chord.

The only unknown variable (other than acc.) is T, so we need anther equation that has T.

This is where we have to consider the torque caused by the cord that makes the cylindrical reel spin on its axis, using the equation: $\tau = I\alpha$, which we then have to brake down into its constituent variables:

$\tau = I\alpha$

$Tr = (\frac{1}{2}Mr^2)(a/r)$,

Where: T is tension, r is the radius, $(\frac{1}{2}Mr^2)$ is the inertia of the reel, and a is the t angential acceleration which is the very same acceleration we are looking for.

Note also that we replace α using the equation $\alpha = a/r$

This equation can then be simplified to:

$T = \frac{1}{2}Ma$

which we then can plug back into the first equation we used:

$mg - T = ma$

$mg - \frac{1}{2}Ma = ma$

$a = mg / (m + \frac{1}{2}M) = 3.3\ m/s^2$

13A

To find the minimum mass we have to look at the forces involved that would just cause the left rope to break, which is to analyze the situation just as rotational equilibrium is about to be broken.

If we let the intersection between the right rope and the pole be our pivot point (or axis of rotation), we can calculate that where the bowling ball is located causes a counter-clockwise torque about that point (axis) given by:

$\tau = (mg)(4L/5)$,

where mg is the weight of the ball, and 4L/5 is its distance from the axis.

We also know that just as equilibrium is about to be broken and the left rope snaps, the tension in the left rope had to have been at its maximum, which would have created a clockwise torque about the pivot point, given by:

$\tau = (T_M)(L)$

Since at the breaking point of equilibrium the net torque is supposed to equal zero, the two opposing torques should equal each other:

$(mg)(4L/5) = (T_M)(L)$, and after the L's cancel out we can solve for mass

$m = 5T_M/4g$

14C

This is an equilibrium problem where the net torque has to equal zero. Realize that the upward support forces given by the piers are another way of asking for the normal forces acting on the bridge. Like usual, we should draw a free-body diagram to show the locations of all our forces acting on the bridge and their relative distances from one another. Then we must pick a pivot point before we set up our torque equation. Usually I'd say that it doesn't matter which end you pick for your rotational axis (left or right pier) except that since we are specifically solving for the normal force coming from the right pier we want to make sure that that variable is present in our net torque equation. So we must pick the left pier, to ensure this. Notice then that the weights of the truck and the bridge are both trying to create a clockwise torque about the left-pier pivot point, while the normal force from the right pier is trying to create a counter-clockwise torque. Since the net torque is zero, we know that the clockwise torques are equal to the counter-clockwise torque. (Remember that although the normal force from the left pier is perpendicular to the bridge, it is located at a distance of $d = 0$ from the pivot point, and so it contributes zero torque about that point).

Finally we set up our equation:

$$(mg)20 + (Mg)25 = (n_{right})50,$$

where mg is the weight of the truck and Mg is the weight of the bridge.

Since the only unknown variable is n_{right} we can solve and get 28.5 kN.

15B

The variables needed to solve for the rotational kinetic energy of the cylinder are its inertia (which is given) and its angular speed. If, at the instant we are interested in, the bucket is moving at 8 m/s, then the tangential speed of the cylinder must also be 8 m/s, since they are connected by the rope.

Knowing this we can quickly convert from velocity to angular speed, $\omega = v/r = 200$ rad/s.

Now we simply have to plug everything in to the equation for kinetic energy:

$\frac{1}{2}I\omega^2 = 2500$ J