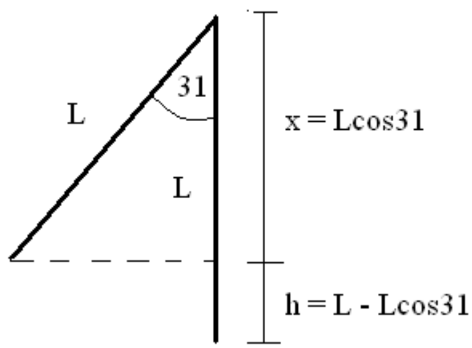
Solutions – PHYS 250 Exam 2 Practice Test

1C



This questions really deals with conservation of energy, ΔK +ΔU = 0.

The main problem is determining the initial height, h, of the man just as he starts to swing.

The diagram above shows how the length of the rope, L, can be split into L = x + h, and how we can solve for the height using trig.

So we get the following equation:

$$\left(\tfrac{1}{2}mv_f^{\,2} - \tfrac{1}{2}mv_i^{\,2}\right) + (0 - mgh) = 0$$
$$v_f = 6.77 m/s$$

2E

This is another conservation of energy question, though this time we have friction, so we get: ΔK + ΔU = W(friction)

This breaks down to $\tfrac{1}{2}mv_f^{\,2} - mgh = -\mu mg\cos 40(6.22)$, where 6.22 is the distance the block travels down the incline given by (h/sin40).

From this the mass cancels out and v = 6.03 m/s

3C (NOT ON TEST)

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.

4B

We know that $\Delta K = W_{net}$

So we re-write Work into its components, $W_{net} = Fd + -\mu mgd$

We then solve for F, and get F = 9.96 N

5B

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

6A

The easiest way to do this is to recognize that the two momentums are at right angles and thus their vectors can be combined using Pythagorean theory.

Since momentum is conserved p(initial) = p(final) and we can write: $(p_x)^2 + (p_y)^2 = p^2$

This becomes $(3m)^2 + (4m)^2 = (v2m)^2$

And then $25m^2 = 4m^2v^2$, and we get v = 2.5 m/s after the masses cancel out.

7D (NOT ON TEST)

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.

8A

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
$m = 5T_M/4g$

9D

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:

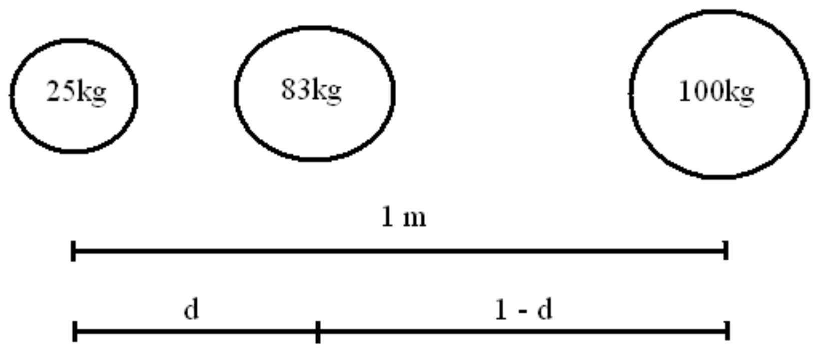
$$a = GM / 2r^2 = \tfrac{1}{2}(GM / r^2)$$

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.

10C

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:

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

11C

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.

12E

Ok remember that radial component means pointing towards the center, and so they are referring to the centripetal acceleration, a_c, which is equal to v^2/r. So we need the velocity and the radius of the circular path, which is already given.

We can easily get the velocity by remembering that $v = \omega r = 4 \times 2 = 8$ m/s.

And if we plug that into the equation for a_c we get 32 m/s^2.

13D

Tangential acceleration is the linear kind that is perpendicular to centripetal acceleration. This one is best calculated if we can get the angular acceleration using the equation

$a_t = \alpha r$.

We can get α using the equation

$\omega = \omega_0 + \alpha t$, $\alpha = (4-0) / 0.5 = 8$ rad/s^2.

And finally $a_t = 8 \times 2 = 16$ m/s^2.

14A

Since the ball's motion is vertical, the weight component will not always be in the same direction relative to the tension (which will always point towards the center). For example, at the top of the circle both the tension and weight will point down towards the center, while at the bottom the tension will point up and the weight vector will point down. Our goal is to figure out what is the largest constant speed that we can use at all points along the circle without the string breaking. Experience tells us that the bottom of the circle is where the tension will most be put to the test since it will have to contend with the weight component acting against it, so that is likely where we will have to calculate our speed.

At the bottom we get the following equation:

$$F_C = T - mg = \frac{mv^2}{r}$$

With the mass, tension, and radius already given, we can solve for velocity and get v = 11.1 m/s.

15E

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:

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

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:

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