Physics Exam 2 Corrections

Amanda Mengotto

November 10, 2015

1 Three Static Masses on an Inclined Plane

b. Masses $m_1 = 6kg$, $m_2 = 4kg$, and $m_3 = 1kg$ are stacked in a corner elevated at an angle $\theta = 15$ degrees. This question asks us to draw free body diagrams for each mass and determine the magnitude of all forces acting on each mass. We can start with mass 3. We know that

$$F_g = m_3 g = (1)9.8N = 9.8N$$

Now, knowing F_g for mass 3, we can calculate the force of 2 on 3.

$$F_{2,3} = m_3 g \cos(\theta)$$

$$F_{2,3} = (1)(9.8)\cos(15) = 9.46N$$

We can apply Newton's 3rd Law to proves that $F_{2,3}$ is equal and opposite in direction to $F_{3,2}$.

$$F_{2,3} = F_{3,2} = 9.46N$$

2 Modified Atwood's Machine

This question asks us to determine the acceleration, tensions, and force of friction for a modified Atwood's Machine. First, we should determine the acceleration. We can look at the machine as one system moving from left to right, where the positive direction is up and to the right. Our first step is to determine the force of friction. We know that $\mu_k = 0.2$ and $m_2 = 4kg$.

$$F_f = \mu_k F_N = \mu_k m_2 g$$

$$F_f = (0.2)(4)(9.8)$$

$$F_f = 7.84N$$

We can now determine the acceleration. Newton's 2nd Law states that $F_{net} = ma$.

$$F_{net} = ma$$

$$m_3 g - F_f - m_1 g = (m_1 + m_2 + m_3)a$$

$$78.4 - 7.84 - 9.8 = 13a$$

$$a = 4.67m/s^2$$

Now that we know the acceleration of the system, we can solve for T_1. Again, we can apply Newton's 2nd law to the portion of the Atwood's Machine containing T_1 and m_1.

$$F_{net} = ma$$
$$T_1 - m_1 g = m_1 a$$
$$T_1 = m_1 a + m_1 g$$
$$T_1 = 1(4.67) + 1(9.8)$$
$$T_1 = 14.5N$$

We can also solve for T_2 by applying Newton's 2rd Law to the portion of the Atwood's Machine containing T_2 and m_3.

$$F_{net} = ma$$
$$m_3 g - T_2 = m_3 a$$
$$T_2 = m_3 g - m_3 a$$
$$T_2 = (78.4) - (8)(4.67) = 41.0N$$

Next, we are asked to determine the work done by the force of friction. **Work** is the accumulated effect of a force acting over some distance. We have already calculated the force of friction, $F_f = 7.84N$. Now we must calculate its work.

$$W_{friction} = F_f \Delta x$$
$$W_F = (-7.84)(0.3) = -2.35J$$

We are asked to calculate the change in Kinetic Energy if the system moves 0.3 meters. It is true that ΔKE is equal to the net work. To determine the net work, we must calculate each individual work and add them together. We can start by calculating the work done by gravity:

$$W_{gravity} = m_3 g \Delta x - m_1 g \Delta x$$
$$W_g = (m_3 - m_1) g \Delta x$$
$$W_g = (8 - 1)(9.8)(0.3) = 20.58J$$

Now we can add the work done by gravity and the work done by friction:

$$W_{net} = 20.58 - 2.35 = 18.2J = \Delta KE$$

3 1D Collisions

Received full credit on collision problems.

4 The Moon

This question first asks us to determine the force the earth exerts on the moon. To do this, we can use Newton's Law of Universal Gravitational Force. The law states that

$$F_g = \frac{mMG}{r^2}$$

We can then plug in the given mass of the earth, mass of the moon, distance between them, and the constant G.

$$F_g = \frac{(7.36x10^{22})(5.98x10^{24})(6.67x10^{-11})}{(3.84x10^8)^2} = 1.99x10^{20}N$$

Next, we are asked to determine the velocity of the moon. The table on page 1 gives us the orbital period of the moon. The distance is the circumference ($2\pi r$) of the moon's circular path.

$$D = 2\pi(3.84x10^8)$$

$$V_{moon} = \frac{2\pi(3.84x10^8)}{(27.3x24x60x60} = 1020m/s$$

We are then asked to calculate the potential, kinetic, and total mechanical energy of the moon. To calculate PE we use a similar formula to the one used to calcualte F_g.

$$PE_{moon} = \frac{mMG}{r}$$

We can plug in the mass of the moon and earth, the radius of the moon, and the constant G to get:

$$PE_{moon} = -\frac{(7.36x10^{22})(5.98x10^{24})(6.67x10^{-11})}{(3.84x10^8)} = -7.64x10^{28}J$$

We know that the formula for Kinetic Energy is $KE = \frac{1}{2}mv^2$.

$$KE_{moon} = \frac{1}{2}(7.36x10^{22})(1020)^2 = 3.83x10^{28}J$$

The total energy is the sum of the kinetic and potential energies. The total mechanical energy is negative, as the moon is in a bound orbit.

$$E = KE + PE$$

$$E = (3.83x10^{28}) + (-7.64x10^{28} = -3.83x10^{28}J$$

Finally, we are asked to determine the escape velocity of the moon. The formula for the escape velocity is

$$V_{esacape} = \sqrt{\frac{2mg}{r_{moon}}}$$

We can plug in the values we know to determine the escape velocity.

$$V_{esacape} = \sqrt{\frac{2(7.36x10^{22})(6.67x10^{-11})}{(1.74x10^6)}} = 2,380m/s$$

5 Pea Shooter

The spring being pulled back powers the pea shooter for many shots, not just one. The mass of a pea is 0.001 kg. The spring has been compressed 0.05 meters and it has 25 Joules of potential energy. We are asked to determine the k constant of the spring. We know that:

$$PE_{spring} = \frac{1}{2}k(\Delta x)^2$$

We can rearrange this to solve for k.

$$k = \frac{2PE}{(\Delta x)^2}$$

Next, we plug in the known values to get:

$$k = \frac{(2(25)}{(5x10^{-2})^2} = 2x10^4 N$$

We can find the average recoil force, F, using the following formula:

$$F = \frac{\Delta p}{\Delta t}$$

First, let us calculate Δp:

$$\Delta p = mV_f - mV_i$$

$$\Delta p = (10^{-3})(15)$$

Now we can plug in Δp and Δt in our equation and solve for F.

$$F = \frac{\Delta p}{\Delta t}$$

Next we are asked to determine the power of the pea shooter. We know that power is equal to the work that the pea shooter does over the time that it does it in.

$$P = \frac{Work}{\Delta t}$$

We also know that Work is really Force dotted into the change in x.

$$P = \frac{F \cdot \Delta x}{t}$$

The force is not constant though - we have a variable force and variable amount of time. However, we know that the Work is equal to the change in Kinetic Energy. So when calculating Power, we can replace W with ΔKE.

$$P = \frac{\Delta KE}{\Delta t} = \frac{\frac{1}{2}mv^2}{\Delta t}$$

We then see that the power is 0.338 Watts:

$$P = \frac{\frac{1}{2}(0.001kg)(15)^2}{\frac{1}{3}} = 0.338 Watts$$

The next thing we are asked to determine is how many peas the peashooter can shoot before running out of spring energy. We know it started with 25 J of Potential Energy in the spring. First, we must figure out the amount of time the peashooter will shoot for. We can determine the time from our previous calculation regarding Power.

$$\Delta t = \frac{W}{P} = \frac{25}{0.338} = 74 sec$$

Next, we can take the rate at which the peashooter shoots (3 peas per second) and multiply this by the amount of time the pea shooter will shoot for.

$$74sec\frac{3peas}{1sec} = 222peas$$