St John Baptist De La Salle Catholic School, Addis Ababa

Grade 11 Physics Midterm Review Questions and Solutions
3rd Quarter

March, 2022

No notes, or other aids are allowed. Read all directions carefully and write your answers in the space provided. To receive full credit, you must show all of your work.**You can use a calculator**.

Name:______________________________ Roll Number:______

1. (2 points) What can be said about Normal force and Friction?
   - A. Normal force is always equal to weight.
   - B. The magnitude of the normal force depends on the axis we choose.
   - C. Friction is directly proportional to normal force. **(Correct Answer)**
   - D. The ratio of normal force to frictional force is almost always less than one.

2. (2 points) How is force different from other physical quantities such as energy and mass?
   - A. Force is an interaction between objects, thus, we need at least two objects force a force to exist.**(Correct Answer)**
   - B. The same way an object can have energy, it also has force. Gravity can be a prime example. An object at a given height can have potential energy due to its position, and gravity also acts on the object since it is at a position where gravitational field acts.
   - C. Since forces are important for energy to exist, both force and energy need more than one body to be felt.
   - D. None

3. (2 points) Which of the following is true about collisions?
   - A. The kinetic energy after collision will always be much less than before the collision.

B. Linear momentum is conserved if there is a net force acting on the system.

C. Linear momentum is conserved in both elastic and inelastic collisions.**(Correct Answer)**

D. Linear momentum and kinetic energy are conserved only during elastic collisions.

4. (2 points) What is the force present when the sun uses nuclear fusion to join atoms of Hydrogen to make Helium and release energy?

   A. Gravitation

   B. Strong Nuclear

   C. Weak Nuclear**(Correct Answer)**

   D. None of the above

5. (2 points) Which of the following is true about an object in space?

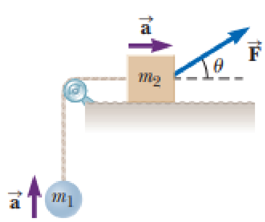
   A. There is no way of telling that the object is moving unless we use a reference point.**(Correct Answer)**

   B. The object has a force.

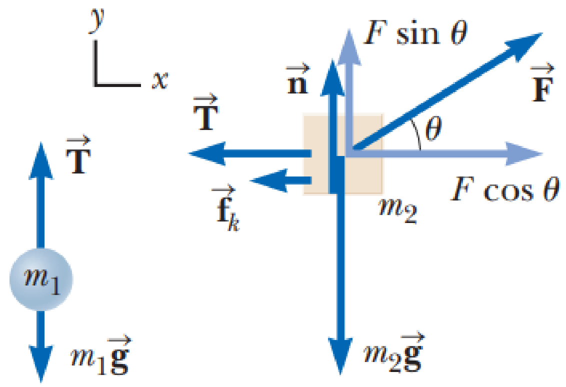
   C. If there is another object in space, we can't tell if one is moving relative to the other.

   D. Motion is absolute, so we know if the object is moving is or not.

6. (3 points) A block of mass m_2 on a rough, horizontal surface is connected to a ball of mass m_1 by a lightweight cord over a lightweight, frictionless pulley as shown in the figure below. A force of magnitude F at an angle θ with the horizontal is applied to the block as shown, and the block slides to the right. The coefficient of kinetic friction between the block and surface is μk. Determine the magnitude of the acceleration of the two objects.



Solution:
The first thing to do to simplify this problem is to define axes and draw the free body diagram and see which forces act on which axes. If we separate the forces according to their axes, we get the diagram in the next page:



Assuming that we have an inextensible string, the tension stays the same through out. Because the two objects are connected, we can equate the magnitudes of the x component of the acceleration of the block and the y component of the acceleration of the ball and call them both **a**.

$$\sum F_x = Fcos\theta - f_k - T = m_2\mathbf{a} \text{ - the Net Force on the box along the X-axis}$$

$$\sum F_y = F_n + Fsin\theta - m_2g = 0 \text{ - the Net Force on the box along the Y-axis}(\textbf{Why 0?})$$

$$\sum F_y = T - m_1g = m_1\mathbf{a} \text{ - the Net Force on the ball along the Y-axis}$$

When we solve the second equation for F_n, we get

$$F_n = m_2g - Fsin\theta, \text{ but}$$

$$f_k = \mu_k F_n$$

$$f_k = \mu_k(m_2g - Fsin\theta)$$

We know from the first equation above that,

$$Fcos\theta - \mu_k(m_2g - Fsin\theta) - T = m_2\mathbf{a}$$

But,

$$T = m_1\mathbf{a} + m_1g. \text{ Thus,}$$

$$Fcos\theta - \mu_k(m_2g - Fsin\theta) - (m_1\mathbf{a} + m_1g) = m_2\mathbf{a}$$

$$Fcos\theta - \mu_k m_2g - \mu_k Fsin\theta - m_1\mathbf{a} - m_1g = m_2\mathbf{a}$$

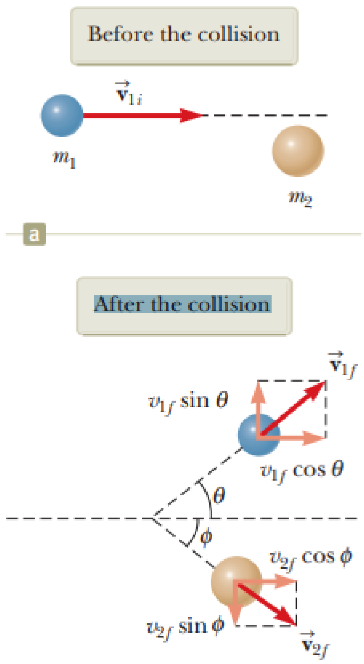
$$Fcos\theta - \mu_k m_2g - \mu_k Fsin\theta - m_1g = m_2\mathbf{a} + m_1\mathbf{a}$$

$$Fcos\theta - \mu_k m_2g - \mu_k Fsin\theta - m_1g = \mathbf{a}(m_2 + m_1)$$

$$\frac{Fcos\theta - \mu_k m_2g - \mu_k Fsin\theta - m_1g}{m_1 + m_2} = \mathbf{a}$$

$$\mathbf{a} = \frac{F(cos\theta - \mu_k sin\theta) - g(\mu_k m_2 + m_1)}{m_1 + m_2}$$

7. (5 points) A proton collides elastically with another proton that is initially at rest. The incoming proton has an initial speed of 3.50×10^5m/s and makes a glancing collision with the second proton as in the figure below. (At close separations, the protons exert a repulsive electrostatic force on each other.) After the collision, one proton moves off at an angle of 37.0^0 to the original direction of motion and the second deflects at an angle of ϕ to the same axis. Find the final speeds of the two protons and the angle ϕ.



If the collision is elastic, we have the following. Let's consider the mass of protons to be **m**. Thus, we have these two cases:

$$KE_i = KE_f$$

Since the collision is elastic, the Kinetic Energy before the collision is the same as the kinetic energy after collision.

$$\frac{1}{2}mV_{1i}^2 = \frac{1}{2}mV_{1f}^2 + \frac{1}{2}mV_{2f}^2$$

We also know that the linear momentum is conserved, thus we have the following.

$$mV_{1i} = mV_{1f} + mV_{2f}$$

Since momentum is a vector, we have to conserve the momentum in each dimension. Thus, we see the following:

1. $V_{1i} = V_{1f}cos\theta + V_{2f}cos\phi$, momentum Conservation along the X-axis

2. $0 = V_{1f}sin\theta - V_{2f}sin\phi$, momentum Conservation along the Y-axis

3. $V_{1i}^2 = V_{1f}^2 + V_{2f}^2$, KE Conservation - we don't consider axes here

If we rearrange equations 1 and 2, we get the following.

$$V_{2f}cos\phi = V_{1i} - V_{1f}cos\theta$$

$$V_{2f}sin\phi = V_{1f}sin\theta$$

Let's square both equations and then add them together.

$$(V_{2f}cos\phi)^2 = (V_{1i} - V_{1f}cos\theta)^2$$

$$(V_{2f}sin\phi)^2 = (V_{1f}sin\theta)^2$$

Then we get:

$$V_{2f}^2cos^2\phi = V_{1i}^2 - 2V_{1i}V_{1f}cos\theta + V_{1f}^2cos^2\theta$$
$$V_{2f}^2sin^2\phi = V_{1f}^2sin^2\theta$$

When we add the equations together,

$$V_{2f}^2cos^2\phi + V_{2f}^2sin^2\phi = V_{1i}^2 - 2V_{1i}V_{1f}cos\theta + V_{1f}^2cos^2\theta + V_{1f}^2sin^2\theta$$

Since the sums of the squares of the sines and cosines of angles are 1, we get the following:

$$V_{2f}^2 = V_{1i}^2 - 2V_{1i}V_{1f}cos\theta + V_{1f}^2$$

We have seen from equation 3 above, that

$$V_{1i}^2 = V_{1f}^2 + V_{2f}^2$$

If we substitute the result we got into the equation above, we get:

$$V_{1i}^2 = V_{1f}^2 + (V_{1i}^2 - 2V_{1i}V_{1f}cos\theta + V_{1f}^2)$$

$$V_{1f}^2 - V_{1i}V1fcos\theta = 0$$
$$V_{1f}(V_{1f} - V_{1i}cos\theta) = 0$$

This implies either $V_{1f} = 0$ or $V_{1f} - V_{1i}cos\theta = 0$ In the second, case:

$$V_{1f} - V_{1i}cos\theta = 0$$

$$V_{1f} = V_{1i}cos\theta$$
$$V_{1f} = (3.5 \times 10^5 m/s)(cos37.0^0)$$
$$V_{1f} = 2.80 \times 10^5 m/s$$

From the above equations, we can see that

$$V_{2f} = \sqrt{V_{1i}^2 - V_{1f}^2}$$

When we put the numbers in, we get the value of V_{2f} to be

$$V_{2f} = 2.11 \times 10^5 m/s$$

From equation two above, we have seen that

$$0 = V_{1f} sin\theta - V_{2f} sin\phi$$

This implies,

$$V_{1f} sin\theta = V_{2f} sin\phi$$

That means,

$$\phi = sin^{-1}(\frac{V_{1f} sin\theta}{V_{2f}})$$

When we put our numbers in, we get the value of ϕ to be

$$\phi = 53.0^0$$