St John Baptist De La Salle Catholic School, Addis Ababa

Grade 11 Physics Midterm Examination

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) Which of the following is true?
   A. If the acceleration of a system is zero, there are no external forces acting on it.
   B. A system can have a nonzero velocity while the net external force on it is zero.(**Correct Answer**)
   C. Newton's Second Law is also called the Law of Inertia.
   D. A body moving with a constant speed around a circle does not accelerate.

2. (2 points) Suppose you catch a baseball and then someone invites you to catch a bowling ball with either the same momentum or the same kinetic energy as the baseball. Which would you choose?(The mass of a bowling bowl is larger than that of a baseball)
   A. The same momentum(**Correct Answer**)
   B. The same kinetic energy
   C. No change
   D. None

3. (2 points) Which of the following is not true about a perfectly inelastic collision?
   A. The kinetic energy after collision will be much less than before the collision.
   B. Linear momentum is conserved.
   C. The colliding masses stick together after collision.
   D. The kinetic energy of the objects is conserved.(**Correct Answer**)

4. (2 points) What is the dominant force between astronomical objects? Why are the other three basic forces less significant over these very large distances?

   A. Gravitation(**Correct Answer**)

   B. Electromagnetism

   C. Dark Energy

   D. None of the above

5. (2 points) Which of the following is true about an object rolling down an inclined plane?

   A. The acceleration of the object is higher if the mass is higher

   B. The object will experience a friction in the same direction as its motion

   C. The frictional force on the body will depend on the angle of the incline(**Correct Answer**)

   D. The object's kinetic energy will be conserved.

6. (3 points) A 0.0250-kg bullet is accelerated from rest to a speed of 550 m/s in a 3.00-kg rifle. The pain of the rifle's kick is much worse if you hold the gun loosely a few centimeters from your shoulder rather than holding it tightly against your shoulder. (a) Calculate the recoil velocity of the rifle if it is held loosely away from the shoulder. (b) How much kinetic energy does the rifle gain?

Solution:

(a)

We will use the conservation of linear momentum to attempt to solve this problem. We see that this is a classic reverse example of a perfectly inelastic collision. We have the rifle and the bullet mass together before the the bullet is fired and after it is fired, we have the separate momenta.

$$(m_1 + m_2)V_i = m_1 V_{1f} + m_2 V_{2f} \text{ Momentum is Conserved}$$

Initially, We have the combined mass, but after the bullet is fired, they have separate velocities. Since $V_i = 0$,

$$m_1 V_{1f} = -m_2 V_{2f}$$

Let m_1 be the mass of the bullet and m_2 be the mass of the rifle.

Thus,

$$(0.0250kg)(550m/s) = -(3.00kg)(V_2)$$

$$V_2 = -4.583m/s$$

The negative velocity indicates that the bullet and the rifle move in opposite directions.

(b)

Initially, we have the kinetic energy of the system to be zero. Therefore, the gained kinetic energy is the final kinetic energy of the system.

$$K.E_f = \frac{1}{2}mV_f^2$$
$$K.E_f = \frac{1}{2}(3.00kg)(-4.58m/s))^2$$
$$K.E_f = 31.5J$$

7. (5 points) A 50 kg skateboarder on a 4 kg board is training with a 3 kg weight. Beginning from rest, she throws the weights horizontally, from her board. The velocity of the weight relative to her after it is thrown is 4m/s to the right. Assume the board rolls without friction. What is her velocity after throwing the weight?(Note the relative velocity) **Solution:**

Here we have a system with multiple masses. Thus, we have to consider the momentum of each object when considering the total momentum of the system.

The momentum of the system after the skateboarder throws the training mass is equal to the momentum after the mass is thrown. Thus,

$$P_i = P_f$$

Initially, before the weight is thrown, her velocity is 0 and everything is at rest relative to the ground. Thus, the initial momentum is 0.

$$P_f = 0$$

That means, the sum of the linear momenta of the objects in the system must result in a net zero situation(*peep the pun*).

We know that after the mass is thrown, the skateboarder along with the board move along with a combined velocity of V_{sb} the weight moves with a velocity of V_w, if we consider our positive X-axis to be the right direction.

Let the masses of the weight, skateboarder and the board be m_w, m_s and m_b respectively. Then, we have:

$$P_f = (m_s + m_b)V_{sb} + m_w V_w$$
$$0 = (50kg + 4kg)V_{sb} + 3kg(V_w)$$
$$(54kg)V_{sb} = -3kg(V_w)$$
$$V_{sb} = -\frac{V_w}{18}$$
$$V_w = -18V_{sb}$$

We know the relative velocity of the weight with respect to the skateboarder to be 4m/s. Thus,

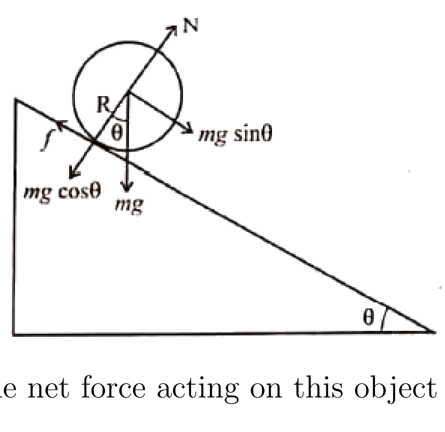
$$V_w - V_{sb} = 4m/s$$
$$-18V_{sb} - V_{sb} = 4m/s$$
$$-19V_{sb} = 4m/s$$
$$V_{sb} = -0.210m/s$$

That means, the velocity of the skateboarder(along with the board) relative to the ground is

$$V_{sb} = -0.210m/s$$

8. (2 points) Derive and expression for the acceleration of an object rolling down an incline. Show that the acceleration is not dependent on the mass and draw a free body diagram. (Consider the coefficient of friction between the object and the incline to be μ)

Solution:



The net force acting on this object along the Y-axis is 0.

$$\sum F_Y = F_N - mgcos\theta, \text{ but, } F_Y = 0$$

$$F_N = mgcos\theta$$

But, the sum of forces along the X-axis is friction:

$$\sum F_x = mgsin\theta - F_f = ma, \text{ but we know that friction is}$$

$$F_f = \mu F_N = \mu mgcos\theta$$

$$mgsin\theta - \mu mgcos\theta = ma \text{ the mass cancels out on each side of the equation}$$

$$gsin\theta - \mu gcos\theta = a$$

$$a = g(sin\theta - \mu cos\theta)$$

9. (5 points) Two football players collide head-on in midair while trying to catch a thrown football. The first player is 95.0 kg and has an initial velocity of 6.00 m/s, while the second player is 115 kg and has an initial velocity of –3.50 m/s. What is their velocity just after impact if they cling together? What kind of collision is this?

Solution:

Let the mass of the first player be m_1 and that of player 2 be m_2.
Since linear momentum is conserved, we have the following

$$P_i = P_f$$

$$m_1V_{1i} + m_2V_{2i} = m_1V_{1f} + m_2V_{2f}$$

But we see that after collision, the players have a common velocity, V_f

$$m_1V_{1i} + m_2V_{2i} = V_f(m_1 + m_2)$$

$$V_f = \frac{m_1V_{1i} + m_2V_{2i}}{m_1 + m_2}$$

$$V_f = \frac{(95.0kg)(6.00m/s) + (115kg)(-3.50m/s)}{95.0kg + 115kg}$$

$$V_f = \frac{167.5kgm/s}{210kg}$$

$$V_f = 0.797m/s$$

This kind of collision is called **perfectly inelastic**, and is recognized by the masses sticking after collision.

10. (5 points) Two identical objects (such as billiard balls) have a one-dimensional collision in which one is initially motionless. After the collision, the moving object is stationary and the other moves with the same speed as the other originally had. Show that both momentum and kinetic energy are conserved.

Solution:

Since both objects have the same mass, let's consider both masses are **m**.

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

The given proposition is that $V_{2i} = 0$(since one of the masses is initially at rest), $V_{1f} = 0$, and $V_{2f} = V_{1i}$ (since the second mass gets the initial velocity of the first mass.)

This implies,

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

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

Let

$$V_{1i} = V_{2f} = V$$

Now, let's see how the momentum is conserved.

$$P_i = mV1i = mV$$

$$P_f = mV2f = mV$$

This implies that $P_i = P_f$, which means that the momentum is conserved

Let's look at Kinetic Energy conservation.

$$K.E_i = \frac{1}{2}mV1i^2 = \frac{1}{2}mV^2$$

$$K.E_f = \frac{1}{2}mV2f^2 = \frac{1}{2}mV^2$$

This implies that $K.E_i = K.E_f$, which means that the kinetic energy is conserved

11. (1 point) Show the dimensional analysis of the SI unit of impulse and show why it is the same as the SI unit of linear momentum.

Solution:

We know that impulse, I is;

$$I = F\mathit{\Delta}T$$

$$I = ma\mathit{\Delta}t$$

$$I = m(\frac{s}{t^2})t$$

$$I = m(\frac{s}{t})$$

$$I = [MLT^{-1}]$$

Similarly the dimensional analysis of momentum is:

$$P = mv$$

$$P = m\frac{s}{t}$$

$$P = [MLT^{-1}]$$

Since both dimensional analyses are the same, we can say both have the same SI unit.