St John Baptist De La Salle Catholic School, Addis Ababa

Grade 10 Physics Midterm Examination Solutions

1st Quarter

December, 2022

Notes, and use of other aids is **NOT** allowed. Read all directions carefully and **write your answers in the answer sheet**. To receive full credit, you must show all of your work.

Useful Constants

- $\mathbf{a}_g = 10m/s^2$ - acceleration due to gravity $\mathbf{G} = 6.672 \times 10^{-12} \frac{Nm^2}{kg^2}$ - gravitational constant

Name:_____ Roll Number:_____ Section:____Time Allowed: **45 minutes**

Multiple Choice Questions

1. An object rotates at a rate of about 6 rev/min. What is this in revolutions per second?
   A. 0.1 rev/s B. 12πrad/s C. 0.1 rad/s D. 6 rev/s
   Answer: A

2. If an object is rotating with a constant angular speed, which of the following is false?
   A. There is no torque acting on the object. B. The angular acceleration of the object is zero. C. The angular momentum is conserved. D. We don't need to do work to keep the object in rotation.
   Answer: A

3. What is Kepler's Second Law a result of?
   A. Conservation of Linear Momentum B. Conservation of Charge C. Conservation of Mass D. Conservation of Angular Momentum
   Answer: D

4. The trajectory of planets & celestial bodies around the sun can't be one of the following geometric shapes:
   A. Ellipse B. Hyperbola C. Lemniscate D. Circle
   Answer: C

5. A point mass the is rotating on the x-axis 1m away from it. If its distance is reduced to 25cm, by what factor does its moment of inertia change?
   A. $I_f = \frac{1}{4} I_i$ B. $I_f = 4I_i$ C. $I_f = 16I_i$ D. $I_f = \frac{1}{16} I_i$
   Answer: D

6. When is angular acceleration positive?
   A. Angular acceleration is the rate of change of the displacement and is positive when ω increases.
   B. Angular acceleration is the rate of change of the displacement and is positive when ω decreases.
   C. Angular acceleration is the rate of change of angular velocity and is positive when ω increases.
   D. Angular acceleration is the rate of change of angular velocity and is positive when ω decreases.

   Answer: C

7. According to Kepler's Second Law, we do know that the aerial velocity of planets around the sun is constant. Which of the following is a result of that?
   A. Planets travel with a constant speed during their trajectory.
   B. Planets travel faster when they're farthest from the sun and slower when they're near the sun.
   C. Planets travel faster when they're nearest to the sun and slower when they're farthest from the sun.

D. Seasons occur because of this.

Answer: C

8. What did Cavendish measure on the "Weighing the Earth" experiment?
A. Weight of the Earth B. Acceleration due to gravity C. Gravitational constant D. Mass of the Earth
Answer: C

9. When you push a door farther from the hinges, why does it open more fast?
   A. It opens fast, because the lever arm is shorter so the torque is large.
   B. It opens fast, because the lever arm is longer so the torque is large.
   C. It opens fast, because the lever arm is shorter so the torque is less.
   D. It opens fast, because the lever arm is longer so the torque is less.

   Answer: B

10. What is the gravitational force between two 70.0 kg people sitting 70 m apart?
A. 1 N B. 6.67×10^{-11}N C. 70 N D. 0 N
Answer: B

Work Out

11. Answer the following questions about angular momentum:

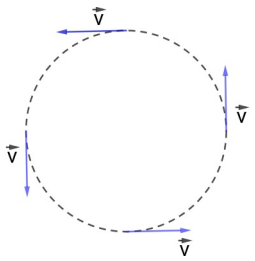
- Show that the torque of a rotating system can be expressed in terms of the time rate of change of the angular momentum.
  Answer

$$\tau_{\text{net}} = \text{I}\alpha$$
$$\tau_{\text{net}} = \text{I}\frac{\Delta\omega}{\text{t}}$$
$$\tau_{\text{net}} = \frac{\text{I}\Delta\omega}{\text{t}}$$
$$\tau_{\text{net}} = \frac{\Delta\text{L}}{\text{t}}$$

- If the net torque on a rotating system is 180Nm and it is acted on for 20 seconds, calculate the angular momentum change it causes.
  Answer

$$\tau_{\text{net}} = \frac{\Delta\text{L}}{\text{t}}$$
$$\Delta\text{L} = \tau_{net}t$$
$$\Delta\text{L} = \tau_{\text{net}}\text{t}$$
$$\Delta\text{L} = 180\text{Nm} \times 20\text{s}$$

12. Consider a CD spinning anticlockwise. What is the sum of the instantaneous velocities of two points on both ends of its diameter?
Answer
Look at the figure below for instance. The velocity pairs on the top & bottom and left & right are pairs at the ends of diameters. If we calculate the sum of the velocity pairs, we can see that they are both opposite, in which case the sum is 0.



13. Prove Kepler's Third Law.(*For the sake of simplicity, assume the path of planets is circular).*
Answer
The proof is available in the notes.

14. Given that the moon orbits Earth each 27.3 days and that it is an average distance of 3.84×10^8m from the center of Earth, calculate the period of an artificial satellite orbiting at an average altitude of 1,500 km above Earth's surface.
Answer
Use Kepler's third law to calculate the period of the satellite.

Since $T^2 \propto R^3$,

$$\frac{T_{moon}^2}{R_{moon}^3} = \frac{T_{satellite}^2}{R_{satellite}^3}$$

$$T_{satellite}^2 = T_{moon}^2 \frac{R_{satellite}^3}{R_{moon}^3}$$

$$T_{satellite} = \sqrt{T_{moon}^2 (\frac{R_{satellite}}{R_{moon}})^3}$$

Input the values given and you should get the period of the satellite.

15. Let there be a hypothetical planet in our solar system that has an average distance of 2AU from the sun. From your proof above, deduce the period of the planet.(*Note that the period of the Earth is 1 year and it is 1AU away from the sun*)

Answer: We use the same method as we did in the question above:

$$T_{planet} = \sqrt{T_{earth}^2 (\frac{R_{planet}}{R_{earth}})^3}$$

When we calculate the period this way, it comes out to $2\sqrt{2}$ years.