St John Baptist De La Salle Catholic School, Addis Ababa
Grade 11 Physics Final Examination
1st Quarter

November, 2023

> 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. **USE OF CALCULATORS IS ALLOWED**.

Name:_____ Roll Number:_____ Section:____Time Allowed: **1.5 hours**

Multiple Choice Questions

Choose the BEST answer out of the given options and mark your answers in the answer box on the last page

(1 points each)

1. Which of the following research repositories is NOT free access?
   A. The arXiv   B. Nature Journal   C. NASA ADS
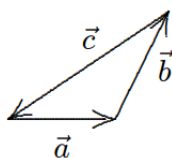   D. Inspire HEP   E. None of the above
   Answer: B

2. Which of the following physics coalitions detected the speed of gravitational waves to be $299,792,858 m/s$?
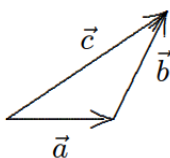   A. WMAP collaboration   B. LISA collaboration   C. CERN Collaboration
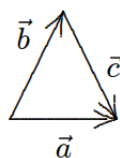   D. LIGO collaboration   E. None of the above
   Answer: D

3. The vectors $\vec{a}$, $\vec{b}$, and $\vec{c}$ are related by $\vec{c} = \vec{b} - \vec{a}$. Which diagram below illustrates this relationship?

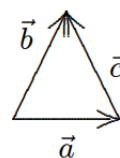   **Answer: D**

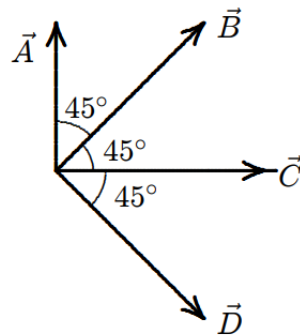4. A vector of magnitude 3 CANNOT be added to a vector of magnitude 4 so that the magnitude of the resultant is:
   A. 0   B. 1   C. 3   D. 7   E. 5
   Answer: A

5. If $|\vec{A} + \vec{B}| = A^2 + B^2$, then which of the following is true?

    A. $\vec{A}$ and $\vec{B}$ must be parallel (*and in the same direction*)

    B. $\vec{A}$ and $\vec{B}$ must be parallel in the opposite direction(*are anti-parallel*)

    C. Either $\vec{A}$ or $\vec{B}$ are zero.

    D. The angle between $\vec{A}$ and $\vec{B}$ is $\dfrac{\pi}{2}$

    E. None of the above is true.

    Answer: D

6. Four vectors $(\vec{A}, \vec{B}, \vec{C}, \vec{D})$ all have the same magnitude. The angle θ between adjacent vectors is 45° as shown. The correct vector equation is

    A. $\vec{A} - \vec{B} - \vec{C} + \vec{D} = 0$ B. $\vec{A} + \vec{B} + \vec{C} + \vec{D} = 0$ C. $\vec{B} + \vec{D} - \sqrt{2}\vec{C} = 0$ D. $\vec{A} + \vec{B} = \vec{B} + \vec{D} = 0$

    E. $\dfrac{\vec{A} + \vec{C}}{\sqrt{2}} = -\vec{B}$

    Answer: C

7. The angle between the vector $\vec{A} = -2.5m\hat{i} + 4.5m\hat{j}$ and the positive x-axis is?
    A. 29°   B. 39°   C. 119°   D. 70°   E. 61°

    Answer: C

8. A vector has a component of 10 m in the +x direction, a component of 10 m in the +y direction, and a component of 5 m in the +z direction. The magnitude of this vector is:
    A. 0   B. 10 m   C. 15 m   D. 25 m   E. 225 m

    Answer: C
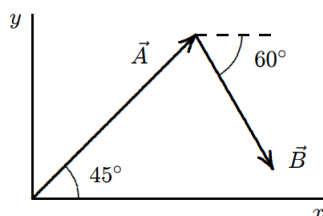
9. In the diagram above, $\vec{A}$ has magnitude 12 m and $\vec{B}$ has magnitude 8 m. The x component of $\vec{A} + \vec{B}$ is about:
    A. 12 m   B. 7.2 m   C. 19 m   D. 20 m   E. 18 m **Answer: A**

10. If the magnitude of the sum of two vectors is less than the magnitude of either vector, then which of the following is necessarily true?

       A. The scalar product of the vectors must be negative

       B. The scalar product of the vectors must be positive

       C. The vectors must be parallel and in opposite directions

       D. The vectors must be parallel and in the same direction

       E. None of the above

Answer: A

11. Let $\vec{R} = \vec{S} \times \vec{T}$ and $\theta \neq 90°$, where θ is the angle between $\vec{S}$ and $\vec{T}$ when they are drawn with their tails at the same point. Which of the following is NOT true?
A. $\vec{R} = |\vec{S}||\vec{T}| \sin \theta$ B. $-\vec{R} = \vec{T} \times \vec{S}$ C. $\vec{R} \cdot \vec{S} = 0$ D. $\vec{R} \cdot \vec{T} = 0$ E. $\vec{S} \cdot \vec{T} = 0$
Answer: E

12. Which of the following quantities is necessarily a fixed vector?
A. Velocity vector   B. Current density vector   C. Position vector   D. Momentum vector
E. None of the above   **Answer: C**

13. Which of the following unit vectors are perpendicular to both $\hat{i} + 2\hat{j} + \hat{k}$ and $3\hat{i} - 4\hat{j} + 2\hat{k}$
A. $\pm\dfrac{\sqrt{165}}{165}(6\hat{i} + \hat{j} - 9\hat{k})$ B. $\pm\dfrac{\sqrt{165}}{165}(4\hat{i} + \hat{j} - 5\hat{k})$ C. $\pm\dfrac{\sqrt{165}}{165}(8\hat{i} + \hat{j} - 10\hat{k})$ D. $\pm\dfrac{\sqrt{65}}{65}(5\hat{i} + \hat{j} - 10\hat{k})$ E. None of the above
Answer: C

14. Three vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$ lie on the same plane. Which of the following is necessarily true?
A. $\vec{A} \times \vec{B} \times \vec{C} = 0$ B. $\vec{A} \times \vec{B} = \vec{C}$ C. $\vec{A} + \vec{B} + \vec{C} = 0$ D. $(\vec{C} \times \vec{A}) \cdot \vec{B} = 0$ E. None of the above
Answer: D

15. What is the value of α for which $(5\hat{i} - 2\alpha\hat{j} + 2\hat{k})$ is perpendicular to the vector $(\hat{i} - \hat{j})$?
A. $\dfrac{-2}{5}$ B. $\dfrac{-5}{2}$ C. $\dfrac{2}{5}$ D. $\dfrac{5}{2}$ E. None of the above   **Answer: B**

16. Which of the following statements is true?

       A. If two vectors $\vec{A}$ and $\vec{B}$ lie on two parallel lines, then $\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}|$

       B. If the $\vec{A} \cdot \vec{B} = 0$, then $|\vec{A}| = 0$ or $|\vec{B}| = 0$

       C. The cross product of a vector with itself is equal to the square of the same vector.

       D. If the dot product of two vectors is maximum, they must be perpendicular.

       E. None of the above.

Answer: E

17. The polar expression for a curve is $r = 1$, which of the following is true?

       A. The curve is an equilateral triangle with all side lengths of 2.

       B. The curve is a unit circle centered at any point in the Cartesian plane.

       C. The curve is a vertical ellipse with eccentricity of 0.8.

       D. The curve is a horizontal ellipse with eccentricity of 1.

       E. None of the above.

Answer: D

18. For what values of x is the vector $x\hat{i} + 3\hat{j} + \hat{k}$ is perpendicular to the vector $x\hat{i} - 3x\hat{j} + 20\hat{k}$?
    A. $x = 1, 10$ B. $x = 4, 5$ C. $x = 0$ D. $x = 1, 10, 90$ E. None of the above.
    Answer: B

19. Vector $\vec{A}$ extends from the origin to a point having polar coordinates $(7, 70°)$ and vector $\vec{B}$ extends from the origin to a point having polar coordinates $(4, 130°)$. What is the value of $\vec{A} \cdot \vec{B}$?
    A. 30   B. 28   C. 14   D. 50   E. None of the above.
    Answer: C

20. When the following equation is converted into its polar form, which one does it become?

$$\frac{4x}{3x^2 + 3y^2} = 6 - xy$$

A. $\dfrac{4\cos\theta}{3r} = 6 - r^2\cos\theta\sin\theta$ B. $\dfrac{6\cos\theta}{2r} = 6 - r^2\tan\theta$ C. $\dfrac{4\cos\theta}{3r} = 1$ D. $r^3 = 1$
Answer: A

21. An electron, which is a lepton, participates in which of the following interactions?
    A. Strong and Gravitational   B. Strong and Weak   C. Electromagnetic and Gravitational
    D. Electromagnetic, Gravitational, and Weak   E. Electromagnetic, Gravitational, and Strong
    Answer: D

22. A down quark can be changed into an up quark (plus other particles perhaps) by which of the following interactions?
    A. Gravity   B. Weak interaction   C. Strong interaction   D. Electromagnetic interaction
    E. None of the above
    Answer: B

23. π^+ represents a pion (a meson), μ^- represents a muon (a lepton), ν_e represents an electron neutrino (a lepton), ν_μ represents a muon neutrino (a lepton) and p represents a proton. Which of the following decays might occur?
    A. $\pi^+ \rightarrow \mu^- + \nu_\mu$ B. $\pi^+ \rightarrow p + \nu_e$ C. $\pi^+ \rightarrow \mu^+ + \bar{\nu}_e$ D. $\pi^+ \rightarrow p + \bar{\nu}_\mu$ E. $\pi^+ \rightarrow \mu^+ + \nu_\mu$
    Answer: E

24. The messenger(force carrier) particles of the strong interaction are called:
    A. W and Z bosons   B. gluons   C. photons   D. kaons   E. gravitons
    Answer: B

25. Two particles interact to produce only photons, with the original particles disappearing. The particles must have been:
    A. mesons   B. strongly interacting   C. leptons
    D. bosons   E. a particle, anti-particle pair
    Answer: E

26. A bus travels 40 kilometers at an average speed of 80 km/h and then travels 40 kilometers at an average speed of 40 km/h. The average speed of the car for this 80-km trip is
    A. 48 km/h   B. 53 km/h   C. 80 km/h   D. 40 km/h   E. 45 km/h
    Answer: B

27. A drag racing car starts from rest at $t = 0$ and moves along a straight line with velocity given by $v = bt^2$, where b is a constant. The expression for the distance traveled by this car from its position at $t = 0$ is:
    A. $2bt$ B. $\dfrac{bt^3}{3}$ C. $\dfrac{2bt^3}{3}$ D. $4bt$ E. None of the above
    Answer: B

28. The position y of a particle moving along the y axis depends on the time t according to the equation $y = at - bt^2$. The dimensions of the quantities a and b are respectively:

   A. $\dfrac{L^2}{T}, \dfrac{L^3}{T^2}$ B. $\dfrac{L}{T^2}, \dfrac{L^2}{T}$ C. $\dfrac{L}{T}, \dfrac{L}{T^2}$ D. $\dfrac{L^3}{T}, \dfrac{T^2}{L}$ E. None of the above

   Answer: C

29. At time t = 0, a car has a velocity of 16 m/s. It slows down with an acceleration given by $a(t) = -0.50t$, in m/s^2 for t in seconds. At the end of 4.0 s, it has traveled:
   A. 14 m   B. 25 m   C. 2 m   D. 59 m   E. None of the above

   Answer: D

30. The average speed of a moving object during a given interval of time is always:

   A. the magnitude of its average velocity over the interval

   B. the distance covered during the time interval divided by the time interval

   C. one-half its speed at the end of the interval

   D. its acceleration multiplied by the time interval

   E. one-half its acceleration multiplied by the time interval.

   Answer: B

Free Response Problems

31. (1 point) Out of the 4 fundamental interactions, state which ones neutrinos interact through. Explain why neutrinos are ironically perfect for astronomy.

   We know that leptons interact through every fundamental interaction except the strong interaction. However, since neutrinos happen to be neutral leptons, they also don't interact through electromagnetism. The fact that they are very little, neutral and barely interact with anything while being so abundant throughout the whole universe makes them a great choice for observational astronomy.

32. (1 point) Given the points O(0, 0, 0), P(1, 2, 3), Q(1, 1, 2), R(2, 1,1), find the volume of the parallelepiped with edges $\overrightarrow{OP}$, $\overrightarrow{OQ}$, and $\overrightarrow{OR}$.

$$\overrightarrow{OP} = \hat{i} + 2\hat{j} + 3\hat{k} \ \& \ \overrightarrow{OQ} = \hat{i} + \hat{j} + 2\hat{k} \ \& \ \overrightarrow{OR} = 2\hat{i} + \hat{j} + \hat{k}$$

   Finding the volume of the parallelepiped is basically finding the cross product of two of the vectors and then computing the dot product of the result with the third vector. In other words, it is:

$$(\overrightarrow{OP} \times \overrightarrow{OQ}) \cdot \overrightarrow{OR} = ((\hat{i} + 2\hat{j} + 3\hat{k}) \times (\hat{i} + \hat{j} + 2\hat{k})) \cdot (2\hat{i} + \hat{j} + \hat{k})$$

   When you compute the result it becomes ± 2

33. (1 point) Find a vector $\vec{u}$ with its given magnitude and that satisfies the following conditions 3 conditions.

   - $\vec{b} = (2\sin t)\hat{i} + (2\cos t)\hat{j} + \hat{k}$
   - $|\vec{u}| = 2$
   - $\vec{u}$ and $\vec{b}$ are anti-parallel.

The simplest way to compute the solution for this is to find $\hat{b}$ and then multiply is by 2 so that the vector $\vec{u}$ has a magnitude of 2 and then again multiply that by negative 1 so that the two vectors are antiparallel. Simply put,

$$\vec{u} = -2\hat{b}$$

$$\vec{u} = -2\frac{\vec{b}}{|\vec{b}|}$$

We then need to find $|\vec{b}|$, which is

$$|\vec{b}| = \sqrt{(2\sin t)^2 + (2\cos t)^2 + (1)^2}$$

$$|\vec{b}| = \sqrt{4\sin^2 t + 4\cos^2 t + 1} = \sqrt{4(\sin^2 t + \cos^2 t) + 1} = \sqrt{5}$$

Now that we have found $|\vec{b}|$, we can find our need vector $\vec{u}$:

$$\vec{u} = -2\frac{\vec{b}}{|\vec{b}|}$$

$$\vec{u} = -2\frac{(2\sin t)\hat{i} + (2\cos t)\hat{j} + \hat{k}}{\sqrt{5}}$$

34. (1 point) Starting at time $t = 0$, an object moves along a straight line. Its coordinate in meters is given by $x(t) = 75t - 1.0t + 3$, where t is in seconds. What is the acceleration of this object when it momentarily stops?

First we need to find $v(t)$ and $a(t)$.

$$v(t) = \frac{dx(t)}{dt} = \frac{75t - 1.0t + 3}{dt} = 75 - 1.0 = 74m/s$$

$$a(t) = \frac{dv(t)}{dt} = \frac{74t^0}{dt} = 0$$

Since the acceleration of the object is always zero, it is also zero when it momentarily stops.

35. (1 point) Two automobiles are 180 kilometers apart and traveling toward each other. One automobile is moving at 50 km/h and the other is moving at 40 km/h. In how many hours will they meet?

Let's consider the one traveling at 50km/h is to the right and the one traveling at 40km/h is to the left. One thing we know for sure is that when they meet, the sum of the distances they will have covered is 180 km. So, based off of that, let's assume the distance traveled by the automobile going to the right is x while the one going to the left is y. We know that the following statement is true,

$$x + y = 180$$

$$50t + 40t = 180$$

$$90t = 180$$

$$t = 2 \text{ hours}$$

36. (2 points) Starting at time $t = 0$, an object moves along a straight line with velocity in m/s given by $v(t) = 98 - 3t^2$, where t is in seconds. At $t = 0$, the object was at a position, $s(0) = -28$. What are the position and acceleration of this object when it momentarily comes to rest.

$$s(t) = \int v(t)dt$$

$$s(t) = \int (98 - 3t^2)dt$$

$$s(t) = 98t - t^3 + C$$

But, we do know that the constant $C = s(0)$. So, our equation becomes

$$s(t) = 98t - t^3 + s(0)$$

$$s(t) = 98t - t^3 - 28$$

As for the acceleration,

$$a(t) = \frac{dv(t)}{dt} = \frac{98 - 3t^2}{dt} = -6t$$

When the object momentarily comes to rest, it means that its velocity is 0 at that instant,

$$v(t) = 0$$

$$98 - 3t^2 = 0 \implies t^2 - \frac{98}{3} = 0$$

So, we know that

$$t = \sqrt{\frac{98}{3}} \text{ or } t = -\sqrt{\frac{98}{3}}$$

We obviously take the positive value of t and plug that it into the $s(t)$ and a(t) values we have come up with. When the car has momentarily come to rest,

$$a = -6(\sqrt{\frac{98}{3}})$$

$$s = 98(\sqrt{\frac{98}{3}}) - (\sqrt{\frac{98}{3}})^3 - 28$$

37. (1 point) What is the acceleration of a car that moves at a steady velocity of 100 km/h for 100 seconds?

The key word here is "steady". It doesn't matter what the velocity of the car is, as long as it is steady for a given time frame, the acceleration is **0**.

38. (1 point) Is it possible for a helicopter to have an acceleration due east and a velocity due west? If so, what would be going on? If not, why not?
Absolutely, yes. An acceleration due East basically means the velocity will be increasing in the eastwards direction. For instance, when the helicopter was traveling to the west and the pilot applied brakes, we have an acceleration due east.

39. (1 point) What is the value of $\hat{i} \cdot (\hat{j} \times \hat{k})$?

$$\hat{i} \cdot (\hat{j} \times \hat{k})$$

$$\hat{i} \cdot (\hat{i})$$

$$1$$