St John Baptist De La Salle Catholic School, Addis Ababa

Grade 10 Physics Final Examination Solutions

2nd Quarter

January, 2022

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

Useful Constants

- $\mathbf{e} = 1.6 \times 10^{-19}$C - elementary charge $\mathbf{m}_e = 9.11 \times 10^{-31}$kg - mass of an electron
- $\mathbf{m}_p = 1.673 \times 10^{-27}$kg - mass of a proton $\mu_0 = 4\pi \times 10^{-7} \frac{H}{m}$ - permeability of free space
- $\epsilon_0 = 8.85 \times 10^{-12} \frac{F}{m}$ - permitivitty of free space $\mathbf{G} = 6.672 \times 10^{-12} \frac{Nm^2}{kg^2}$ - gravitational constant
- $\mathbf{N}_A = 6.022 \times 10^{23} \frac{1}{mol}$ - Avogadro's number $\mathbf{a}_g = 10m/s^2$ - acceleration due to gravity

Name:_____ Roll Number:_____ Section:____Time Allowed: **1:45 hr**

Multiple Choice Questions

1. Which of the following changes to a parallel plate capacitor would not increase the energy stored in a capacitor at a fixed voltage?
   A. Increasing the area of the plates B. Increasing the dielectric constant C. Decreasing the charges on the plate D. Increasing the distance between the plates E. None of the above
   Answer: C

2. An electron enters a region of uniform electric field of 4×10^3 V/m. What is the force on the electron?
   A. 8×10^{-16} N B. 6.4×10^{-16} N C. 8×10^{16} N D. 1.6×10^{-19} N E. None of the above
   Answer: B

3. Which of the following is true about gravitational potential energy?
   A. It is positive because gravity and mass are positive B. It depends on the motion of the body C. It depends on the height above the ground where the body is D. It only depends on initial and final heights E. None of the above
   Answer: D

4. What is the measure of the distribution of mass of a body in relation to its axis of rotation?
   A. Torque B. Angular Momentum C. Moment of Inertia D. Linear Momentum E. None of the above
   Answer: C

5. A point charge Q_1 is at $x = 0$ and another point charge Q_2 is at $x = 4$. What is the relationship between these two point charges if the absolute potential due to these charges is 0 at $x = 8$?
   A. $Q_1 = 4Q_2$ B. $Q_1 = -2Q_2$ C. $Q_1 = -8Q_2$ D. $Q_1 = 4Q_2$ E. None of the above
   Answer: B

6. The potential difference between the terminals of a battery when the battery is isolated is:
   A. Electric Force B. Terminal Voltage C. Electromotive Force D. Electrolytic Voltage
   Answer: B

7. A simple circuit consists of a load resistor of 10Ω connected to a battery of 18V EMF. If the current through the circuit is 1.6A, what is the internal resistance of the battery?
   A. 1.25Ω B. 12.5Ω C. 10Ω D. 1.6Ω E. None of the above **Answer:** A

8. The escape speed at the surface of some planet is twice that of the Earth's escape speed. What is the mass of the planet(M_p) in terms of Earth's mass(M_e)?
A. $M_p = 0.5\ M_e$ B. $M_p = 2\ M_e$ C. $M_p = 4\ M_e$ D. $M_p = 8\ M_e$ E. None of the above
Answer: All the options could be an answer because of we didn't say anything about the radius of the planet. **So, all are correct**.

9. One electron-volt is the same as:
A. 3.6 J B. 1.0 J C. 3.6×10^6 J D. 1.6×10^{-19} J
Answer: D

10. Electric companies usually list their billings in amounts of cents/KWh. For example, the British Power company EON bills consumers 7.3 cents/KWh. In this quantity, KWh is a unit of:
A. Energy B. Power C. Current D. Voltage E. None of the above
Answer: A

11. A 2μF and 1μF capacitors are connected in parallel and a potential difference is applied across the combination. The 2μF capacitor has: A. half the charge of the 1μF capacitor B. twice the stored energy of the 1μF capacitor C. twice the potential difference of the 1μF capacitor D. half the stored energy of the 1μF capacitor E. None of the above
Answer: B

12. A tangent line to an equipotential surface and the electric field due to the same charge at any point must be:
A. Parallel B. Perpendicular C. Opposite in direction D. They don't have any relationship E. None of the above
Answer: B

13. Which of the following is true about resistivity and conductivity?
A. They are reciprocals of one another B. They are dimensionless quantities C. They have direct relationship D. They have the same SI units E. None of the above
Answer: A

14. If two, infinitely long parallel conducting wires carry the same current and the force per unit length on each wire is 2×10^{-7} N/m, the current in each wire is defined to be:
A. 1 Ampere B. 1 Coulomb C. 2×10^{-7} Coulomb D. 2×10^{-7} Ampere E. None of the above
Answer: A

15. The angular impulse experienced by a body is equivalent to the change in:
A. Mechanical energy B. Linear Momentum C. Angular Momentum D. Relativistic Kinetic Energy E. None of the above
Answer: C

16. A 9V battery is connected to a 2μF capacitor. How much electric energy can be stored in the capacitor?
A. 1.62×10^{-5} J B. 8.1×10^{-5} J C. 1.62×10^{-4} J D. 8.1×10^{-4} J E. None of the above
Answer: B

17. The two ends of a 4Ω resistor are connected to a 16V battery. What is the total power delivered by the battery to the circuit?
A. 4 W B. 16 W C. 32 W D. 64 W E. None of the above
Answer: D

18. Electric potential energy is an energy of a charge possessed because it is in the:
A. region of other masses B. vacuum C. region of zero electric field D. region of other charges E. None of the above
Answer: D

19. Two resistors R_1 and R_2 are connected in series. If R_1=$2R_2$, which of the following is true?
A. V_1=$2V_2$ B. V_1=$\frac{1}{2}V_2$ C. I_1=$2I_2$ D. I_1=$\frac{1}{2}I_2$ E. None of the above
Answer: A

20. A 3A current is flowing through a Copper conductor ($n = 8.5 \times 10^{28} m^{-3}$) that has a cross sectional area of 1mm^2. What is the drift speed of the electrons in this conductor?
A. $2.205 \times 10^4 m/s$ B. $2.205 \times 10^{-4} m/s$ C. $2.205 \times 10^{-8} m/s$ D. $2.205 \times 10^{-2} m/s$ E. None of the above **Answer:** B

21. All conductors obey Ohm's Law.
A. True B. False C. None of the above
Answer: B

22. If the value of acceleration due to gravity on the surface of the Earth is **g**, what will its value be at a height equal to the radius of the Earth above the surface?

A. $\frac{\mathbf{g}}{8}$ B. $\frac{\mathbf{g}}{4}$ C. $\frac{\mathbf{g}}{2}$ D. $\mathbf{g}$ E. None of the above
Answer: B

23. What is the potential at a distance of 10m from a charge 0f -5.0C?
A. -4.45×10^9 V B. $+4.45 \times 10^9$ V C. -4.45×10^{-9} V D. $-4.45 \times 10^{+9}$ V E. None of the above
Answer: A, D

24. There are two parallel parallel charged plates in some region. A positive charge of 1.0×10^{-4} C is on the negatively charged plate. If the potential on the positively charged plate is +10KV and the potential on the negatively charged plate is -10KV, how much work is required to move the charge from the negative plate to the positive plate?
A. 2.0 J B. 0.0 J C. 4.0 J D. 1.0 J E. None of the above
Answer: A

25. A charge of $Q_1 = 10 \times 10^{-9}$C is placed at the origin while another charge of $Q_2 = 10 \times 10^{-9}$C is placed at (0,6). What is the electric force on a third charge $Q_3 = -2.5 \times 10^{-8}$C if it is placed at (4,3) due to Q_1 and Q_2?
A. 1.08×10^{-7}N, positive Y direction B. 1.42×10^{-7}N, positive X direction C. 1.42×10^{-7}N, negative Y direction D. 9.00×10^{-7}N, positive Y direction E. None of the above
Answer: Since the units for the coordinates have not been given, all choices are considered correct answers.

Conceptual & Proof Problems

26. What are the factors affecting the resistance of conductor? List each factor and explain the effects of changing the factors on the resistance.

Read page 2 of ***Current Notes***.

27. Show that relation $R = \frac{\rho L}{A}$ follows from the macroscopic form of Ohm's Law($\implies V = IR$) and microscopic form($J = \sigma E$).

Read pages 1&2 of ***Further Notes on Capacitance & Resistance***.

28. Consider a region in space where a uniform electric field points in the positive Y direction.

- What is the orientation of the equipotential surfaces?

  Since equipotential surfaces are perpendicular to electric field lines, if the field points in the positive Y direction, our equipotential surfaces should be along an axis perpendicular to the field - which is the X or Z axes.
- If you move in the negative Y direction, does electric potential decrease or increase?

  We know that electric field is always points from higher potential to lower potential. If I go to the negative Y direction, it is against the field, it means that it is from lower potential to higher potential meaning the potential increases.

Refer to HW6 Solutions for more information.

29. Why are equipotential lines and surfaces perpendicular to the electric field lines?

The work done to move a charge along an equipotential surface is 0. ($W = q\Delta V = q \times 0 = 0$) since $\Delta V = 0$ for an equipotential surface.

$$W = Fd\cos\theta$$

$$0 = Fd\cos\theta$$

This means that $\cos\theta = 0$, where θ is the angle between the equipotential surface and the field line. This implies that $\theta = 90^0$

Refer to HW5 Solutions for more information.

Workout Problems

30. A capacitor in an RC circuit has a capacitance of 40μF while the resistor has a resistance of 20KΩ. If the capacitor is initially empty, answer the following questions: $(Q(t) = Q(1 - e^{-\frac{t}{\tau}}))$

- Calculate the amount of time it would take the charge in the capacitor to reach 63%.

  We know that the time it takes for an empty capacitor to charge up to 63% is τ.

  $$\tau = RC = 40 \times 10^{-6}\text{F} \times 2 \times 10^4\Omega$$

  $$\tau = 0.8\text{sec}$$

- Calculate the amount of charge left when $\frac{2}{5}\tau$ amount of time has dissipated.

  $$Q(t) = Q(1 - e^{-\frac{t}{\tau}})$$

  We have been given that $t = \frac{2}{5}\tau$, thus plugging that in, we get:

  $$Q(t) = Q(1 - e^{-\frac{\frac{2}{5}\tau}{\tau}})$$

  $$Q(t) = Q(1 - e^{-\frac{2}{5}})$$

  If you didn't have a calculator in the exam, as with most students, this is enough simplification. If you want to simplify it further down, you can, but it's not important. The answer above is good enough.

31. How far apart are two conducting plates that have an electric field strength of 6.40×10^3V/m between them, if one of the plates has a potential of -4.0KV and the other has a potential of 6.0KV?

We know that $\Delta V = Ed$, but first let's calculate the potential difference.

$$\Delta V = 6.0KV - (-4.0KV)$$

$$\Delta V = 10.0KV$$

To find the distance between the plates, we can rearrange the equation above to the one below:

$$d = \frac{\Delta V}{E}$$

$$d = \frac{10KV}{6.40 \times 10^3 V/m} = \frac{10^4}{6.40 \times 10^3}m = \frac{10}{6.4}m$$

32. On a planet whose radius is **2R**, the acceleration due to gravity at the surface of the planet is **g/3**. What is the mass of the planet in terms of Earth's mass if the radius of the Earth is R and the acceleration due to gravity at the surface of the Earth is **g**?$(g = \frac{GM}{R^2})$

For Earth, we know that $g = \frac{GM}{R^2}$, which measn $M = \frac{gR^2}{G}$. For the planet, $g_p = \frac{GM_p}{R_p^2}$, but we have been given in the question that $g_p = \frac{g}{3}$ while $R_p = 2R$. Plugging in those values in to the planets acceleration due to gravity expression, we get

$$g_p = \frac{GM_p}{R_p^2}$$

$$\frac{g}{3} = \frac{GM_p}{(2R)^2}$$

$\frac{g}{3} = \frac{GM_p}{4R^2}$, expressing M_p in terms of the other variables, we get:

$$M_p = \frac{4gR^2}{3G} = \frac{4}{3} \times \frac{gR^2}{G} = \frac{4}{3} \times M$$

Thus, the planet is $\frac{4}{3}$ times more massive than the Earth.

Extra Credit Problem

33. Calculate the Schwarzschild radius of a hypothetical subatomic particle that has a mass of 700Gev/c^2. Explain why you think if whether that this particle can ever turn into a black hole or not?

To calculate the Swarzschild radius, we know that the escape speed should be **c**. Thus,

$$c = \sqrt{\frac{2GM}{R}}$$

Rearranging variables to express R in terms of the others, we get:

$$R = \frac{2GM}{c^2}$$

For this specific particle we have to convert its mass into kilograms. To do that let's see what 1Gev/c^2 is in terms of kilograms.

$$1Gev/c^2 = 10^9 \times ev/c^2$$

$$1Gev/c^2 = 10^9 \times 1.6 \times 10^{-19}\text{J}/(3 \times 10^8 m/s)^2$$

$$1Gev/c^2 \approxeq 1.78 \times 10^{-27} kg$$

This means, a 700Gev/c^2 particle will weigh $700 \times 1.78 \times 10^{-27} kg \approxeq 1.25 \times 10^{-25} kg$
We can then plug this in to our equation we have above:

$$R = \frac{2 \times 6.67 \times 10^{-11} \times 1.25 \times 10^{-25} kg}{(3 \times 10^8 m/s)^2}$$

$$R = 1.853 \times 10^{-52} m$$

Theoretically, the smallest possible length or quantized distance between two points is the Planck length, which is $1.6 \times 10^{-36} m$, we do see that the Swarzschild radius we found is much, much smaller than the Planck length telling us that the chance of this particle turning into a black hole is zero.