Grade 10 Workbook Problems

St John Baptist De La Salle Catholic School, Addis Ababa

22/23 Academic Year

Chapter 1

1. Define the following terms and explain what relationships they have with respects to projectile motion.

   (i) Trajectory

   (ii) Projectile

   (iii) Air resistance

   (iv) Kinematics

   (v) Drag

2. During a fireworks display, a shell is shot into the air with an initial speed of $64.0 m/s$ at an angle of 65.0^0 above the horizontal. The fuse is timed to ignite the shell just as it reaches its highest point above the ground.

   (i) Calculate the vertical distance above the ground at which the shell explodes.

   (ii) How much time passed between the launch of the shell and the explosion?

(iii) What is the horizontal displacement of the shell when it explodes?

(iv) If the shell didn't explode, calculate the velocity it will have just before touching the ground.

3. Suppose a large rock is ejected during a tectonic activity with a speed of $35.0 m/s$ and at an angle 38^0 above the horizontal. The rock strikes a plateau at an altitude 400.0 m lower than its starting point.

   (i) Calculate the time it takes the rock to follow this path.

   (ii) What are the magnitude and direction of the rock's velocity at impact.

   (iii) What is the highest vertical range of distance it achieves during its trajectory?

4. A person standing on the edge of the rooftop of a skyscraper accidentally throws his phone straight up with an initial velocity of $20.0 m/s$. The rock misses the edge as it falls back to

earth. Calculate the position and velocity of the rock 1.00 s, 2.00 s, and 3.00 s after it is thrown, neglecting the effects of air resistance.

5. Helicopters have a small propeller on their tail to keep them from rotating in the opposite direction of their main lifting blades. Explain in terms of Newton's third law why the helicopter body rotates in the opposite direction to the blades.

6. An ultracentrifuge accelerates from rest to 80,000 rpm in 4.00 min.

   (i) What is its angular acceleration in rad/s^2?

   (ii) What is the tangential acceleration of a point 6.50 cm away from the axis of rotation?

   (iii) What is the radial acceleration in m/s^2 and multiples of g of the point in (ii) at full rpm?

7. Veronica exerts a force of 180 N tangential to a 0.4-m radius 60.0-kg grindstone that is geometrically a solid disk.

   (i) What torque is veronica exerting on the grindstone?

(ii) If the grindstone generates no opposing friction, what is its rotational acceleration?

(iii) What is the angular acceleration if there is an opposing frictional force of 18.0 N exerted 2 cm from the axis?

8. Calculate the angular momentum of a ballerina spinning at 7.00 rev/s given her moment of inertia is $6kg - m^2$.

(i) She reduces her spin rate by extending her arms and increasing her moment of inertia. Find the value of her moment of inertia if her angular velocity decreases to 3 rev/s.

(ii) Suppose instead she keeps her arms in and allows friction of the ice to slow her to 2.00 rev/s. What average torque was exerted if this takes 15.0 s?

9. Given that the mass of the Earth is around 5.96×10^{24} kg, answer the following questions.

(i) Calculate the angular momentum of Earth on its axis.

(ii) What is the angular momentum of Earth in its orbit around the Sun?

(iii) Calculate the rotational kinetic energy of Earth on its axis.

(iv) What is the rotational kinetic energy of Earth in its orbit around the Sun?

10. While getting ready for a free-kick, Addis rotates his leg about the hip joint. The moment of inertia of the leg is $2.8kg - m^2$ and its rotational kinetic energy is 175 J.

(i) What is the angular velocity of the leg?

(ii) What is the velocity of tip of Addis's shoe if it is 1.2 m from the hip joint?

(iii) Explain how the football can be given a velocity greater than the tip of the shoe (necessary for a decent kick distance). (*Hint: think of the effect time has while kicking a ball.*)

11. The Moon and Earth rotate about their common center of mass, which is located about 4700 km from the center of Earth. (This is 1690 km below the surface of the Earth.)

(i) Calculate the magnitude of the acceleration due to the Moon's gravity at that point.

(ii) For a hypothetical asteroid of mass 9000 kg, estimate the force exerted on it by the moon if it is at that point.

12. State three of Kepler's laws and the physical reasoning behind each law.

13. We know 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.

(i) A geosynchronous Earth satellite is one that has an orbital period of precisely 1 day. Such orbits are useful for communication and weather observation because the satellite remains

above the same point on Earth (provided it orbits in the equatorial plane in the same direction as Earth's rotation). Calculate the radius of such an orbit.

(ii) Calculate the period of an artificial satellite orbiting at an average altitude of 2000 km above Earth's surface.

Chapter 2

14. Why must the test charge q in the definition of the electric field be vanishing small?

15. Define the following terms and explain what they are.

    (i) Charge

    (ii) Source and test charges

    (iii) Coulomb Force

    (iv) Electric field strength

    (v) Permittivity of vacuum

    (vi) Electric potential energy, absolute potential, and voltage

(vii) Capacitors

16. Why does electrostatic shock almost always happen when touching nonmetallic surfaces?

17. One important aspect of charge is that it is quantized. How many electrons are needed to form a charge of $-9.6nC$?

18. Suppose a speck of dust in an electrostatic precipitator has 1.8×10^{16}protons in it and has a net charge of –5.00 nC. How many electrons does it have?

19. A test charge of $9nc$ is placed halfway between a charge of $-5\mu C$ and another of $9\mu C$ separated by 8 cm.

    (i) What is the magnitude and direction of the net electric field due to the charges at the position the test charge is located?

(ii) What is the magnitude and direction of the net electric force on the test charge?

20. Two point charges of $3\mu C$ and $-7\mu C$ are placed 40 cm apart.

(i) Where can any test charge be placed such that the net force on the charge due to the point charges above is zero?

(ii) What about if both charges were the same sign?

21. List the properties of electric lines of force and explain the orientation of the lines in relation with electric field strength.

22. A simple and common technique for accelerating electrons can be done by separating two plates of opposite charges where there is a uniform electric field between two plates. Electrons are released, usually from a hot filament, near the negative plate, and there is a small hole in the positive plate that allows the electrons to continue moving. If for instance, the field between two plates of a certain apparatus is $2 \times 10^5 N/C$, answer the following questions.

(i) What is the acceleration of the electrons?

(ii) Why would the electron not be pulled back to the positive plate once it moves through the hole?

23. What is the relationship between potential difference and potential energy? Also, express this relationship mathematically.

24. When measuring voltage, we always measure it between two points. Why is that always the case?

25. What is the relationship between potential energy and electric field strength?

26. Show that the units V/m and N/C are the same units.

27. The electric field strength between two parallel conducting plates separated by 6.00 cm is 7×10^3V/m.

    (i) What is the potential difference between the two plates?

    (ii) Assuming the plate with the lowest potential is taken to be at zero volts. What is the potential 2.00 cm from that plate (and 4.00 cm from the other)?

28. A 2.00 cm diameter plastic sphere, used in a static electricity demonstration, has a uniformly distributed 40.0 nC charge on its surface. What is the potential near its surface?

29. What are equipotential lines and surfaces?

    (i) What is distinct about them?

    (ii) Is work done when moving along equipotential lines? Why?

(iii) Why are equipotential lines perpendicular to electric field lines?

(iv) Can different equipotential lines cross? Explain.

30. Based on the Coulomb force, try to explain why capacitance should be proportional to the plate area of a capacitor. Similarly, explain why capacitance should be inversely proportional to the separation between plates.

31. What is a dielectric? What is the advantage of adding in a dielectric when dealing with capacitors?

32. If you wish to store a large amount of energy in a capacitor bank, would you connect capacitors in series or parallel?

33. What application of a physics concept applies on capacitors? Explain how they work

34. What is time constant? What type of function is the charge as a function of time when a capacitor is charging or discharging?

35. What capacitance is needed to store $60\mu C$ of charge at a voltage of 120 V?

36. If the area of the plates of a parallel plate capacitor are doubled while the distance between them is decreased by a factor of 3, by how much does the capacitance change?

37. What changes can we bring to a capacitor so that it would be able to store more energy?

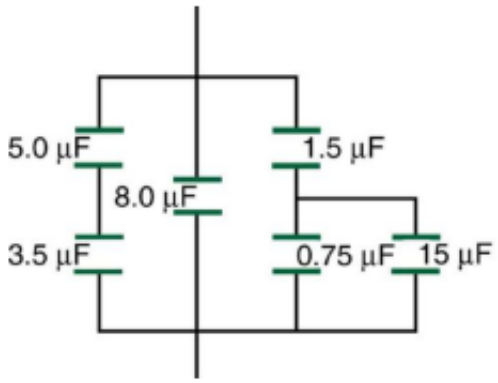
38. A parallel plate capacitor has plates of area that are $1.2cm^2$ separated by 0.0200 mm.

    (i) What is the capacitance of the capacitor?

    (ii) How much energy would it be able to store if we apply a voltage of 4V to its plates.

(iii) What would its new capacitance be if we added a dielectric of permittivity $\varepsilon = 4.40 \times 10^{-11} F/m$?

39. Based on the figure shown below, answer the questions that follow.



(i) Find the effective capacitance of the network.

(ii) If we applied a voltage of 6V between the top and bottom ends of the system, calculate the charge and energy stored in each capacitor.

Chapter 3

40. Define current and explain current in different ways. For example, state why although capacitors can be treated as open switches, current still runs in the circuit.

41. A conducting copper wire has a diameter of 2.228 mm. What magnitude current flows when the drift velocity is 1.00 mm/s?

42. Given that the density of Manganese is $3.7 g/cm^3$ and that we assume that there are 3 mobile electrons per each atom, calculate the electron density of a conducting wire made of Manganese.

43. Power outages are common in Ethiopia and hence rechargeable batteries are common. One such example of battery is a "power bank" that we can use to charge our devices. Aaron's "power bank" boasts a $6000 mAh$ capability. What physical quantity does mAh represent?

44. Why are two conducting paths from a voltage source to an electrical device needed to operate the device?

45. Why isn't a bird sitting on a high-voltage power line electrocuted? What happens when it steps its feet on both wires?

46. Discuss both the macroscopic and microscopic aspects of Ohm's Law.

47. What is the effective resistance of a car's starter motor when 200 A flows through it as the car battery applies 12.0 V to the motor?

48. Find the conductivity and resistivity of a material if it is 50.0 m long with a 0.050 mm diameter and has a resistance of 80Ω at 20^0C?

49. What does ammeter measure? How should it be connected to the circuit? Why? What about a voltmeter?

50. If there are n identical resistors of resistance R in a network and 40% of them are connected in series while the other 60% are connected in parallel, find the effective resistance in terms of n & R.

51. Given a battery, an assortment of resistors, and a variety of voltage and current measuring devices, describe how you would determine the internal resistance of the battery.

52. The hot resistance of a flashlight bulb is 5Ω, and it is run by a 2.8-V alkaline cell having a internal resistance of 0.3Ω.

    (i) What current flows through the bulb?

    (ii) Calculate the power dissipated by the bulb.

    (iii) What is the efficiency of the battery?

53. Show that for two resistors R_1 and R_2, the effective resistance when they are combined is larger when the resistors are in series than when they are in parallel.

Chapter 4

54. Discuss how the Hall effect could be used to obtain information on free charge density in a conductor.

55. Explain why the magnetic field would not be unique (that is, not have a single value) at a point in space where magnetic field lines might cross.

56. List the ways in which magnetic field lines and electric field lines are similar and different.

57. The force per meter between the two wires of a jumper cable being used to start a stalled car is 0.225 N/m.

    (i) What is the current in the wires, given they are separated by 2.00 cm?

    (ii) Is the force attractive or repulsive(*the current carrying wires in a jumper cable run in opposite directions*)?

58. To what direction should an electron be shot so that when it is put in a magnetic field in the direction of the negative Z-axis, the force acting on it is in the positive X-axis?

59. A cosmic ray electron moves at 7.50×10^6 **m/s** perpendicular to the Earth's magnetic field at an altitude where field strength is 1.00×10^{-5} **T**. What is the radius of the circular path the electron follows?

60. Calculate the inductive time constant of a circuit which has an inductor with an inductance of 6mH and a resistor of resistance 300Ω. If the EMF supplied by the battery is 60V, calculate the time needed for the current to drop to 0.1A.

61. Find the magnetic force(both the magnitude and direction) acting on a proton if its velocity is V=$1.6 \times 10^6 \hat{\boldsymbol{j}}$ m/s and it is in a magnetic field of B=$2\hat{\boldsymbol{i}} + 8\hat{\boldsymbol{j}} + 72\hat{\boldsymbol{k}}$T

62. Show that V/H and A/s are the same by doing a dimensional analysis.

63. A long solenoid has 1000 turns uniformly distributed over a length of 0.40m. What current is required in the windings to produce a magnetic field of $\pi \times 10^{-2}$G at the center of the solenoid?

64. How can we decrease the effect of eddy currents?

65. A 15.0 cm long rod moves at 6.00 m/s perpendicular to a magnetic field. What is the strength of the magnetic field if a 95.0 V emf is induced?

66. Calculate the magnetic field strength needed on a 100-turn square loop 18.0 cm on a side to create a maximum torque of 500Nm if the loop is carrying 25.0 A.

67. What is the force and torque on a square-shaped 6A current carrying loop of conducting wire that has an area of $0.0064m^2$ and surrounded by a permanent magnet with a field strength of B $= 3.0 \times 10^5$T that is tilted at 30^0 to the loop?

68. If a charged particle moves in a straight line through some region of space, can you say that the magnetic field in that region is necessarily zero?

69. What is the angle between the current carrying wire and the magnetic field when the force exerted on the wire is half of the maximum force possible?

70. Find the charge to mass ratio of a charge moving if it is moving at a speed of $v = 5.0 \times 10^3 m/s$ in a magnetic field of 0.08G and it has the same trajectory as an electron in the same magnetic field.

71. What is the magnetic field 2cm away due to a straight current carrying wire made of Manganese if the wire has a volume $27cm^3$ and length 3cm, if it is switched on for 5 seconds?

72. A uniform magnetic field of magnitude 1.2 T is directed along the negative y - axis. An electron moving at a speed of $0.2c$ makes an angle of 60^0 with the y - axis. Answer the following questions.

    (i) What is the expected trajectory of the electron?

(ii) Calculate the radius & pitch of the trajectory.

73. What are ferromagnetic materials? What are some common ferromagnetic materials?

74. We have seen that charges and magnets have similar properties. How is a charge similar to and different from a magnet?

75. If a current carrying wire of 2A and length 3m is in a region of space that is perpendicular to a magnetic field of 3T, what is the maximum force on the wire? What about the minimum force?

76. An electron and a proton are shot with the same speed of $3 \times 10^7 m/s$ perpendicular to the magnetic field in question 3. What are the magnitudes of the forces on the electron and the proton? What about the radius of the trajectories by the electron and the proton?

77. A current carrying wire that is carrying a current of 4A is going into the page. What is the magnetic field strength due to the wire 2cm vertically above the wire?(Both B and $\hat{B}$)

78. For two wires both going out of the page, show that the two wires attract.

Chapter 5

79. Let's say we want to study a signal visually. For an AC signal of a maximum voltage 12V and frequency of 60 Hz, draw a visual representation of what we would expect to see on an oscilloscope. You are free to give the oscilloscope the time base and gain control of your choice.

80. State the uses of a transistor and explain how amplification is possible through a double junction. Draw the paths of current in the transistor and state Kirchhoff's Law. Explain why the word "amplification" is misleading while using it for transistors.

81. Explain the difference between P-type and N-type semiconductors and how they are made. Explain how their properties gives rise to rectification. Explain what rectification is and state what the opposite process of rectification is(inversion) and state how we can rectify or invert current.

82. Define and explain the following terms:

    (i) Doping and impurities.

    (ii) Acceptor and Donor atoms.

(iii) Conduction band theory and lattice structures.

83. Explain what we mean by 0 and 1 electrical signals. Explain what logic gates are. Give 3 examples of ligc gates used in real life.

84. In what way can we achieve a full wave rectification?

85. An input of direct current is sent into an unknown electrical device and when current emerges out of the device, the output current is alternating. What device could the unknown be?

86. What is the emission of conduction electrons from the hot meta in a Fermi valve is known as?

87. Why is the Fermi valve referred to as a "valve"?

88. Check whether the logic gates given below are equivalent or not by preparing a table of truth values.

    A. An **AND** and a **NOT-NAND**

    B. An **NOR** and a **NOT**

    C. An **AND** and a **OR**

    D. A **NOT** and an **XOR**

89. What does it mean when a P-N junction is forward biased? What about when it is reverse biased?

90. Why is rectification by a single diode always half-wave?

91. Plot a signal for a CRO measuring a signal of frequency 200Hz and maximum voltage 8V if the gain control is 4V/cm and time base is 2ms/cm.

92. The collector current of a transistor is 4.2 A for a base current of 3.4 mA. What is the current gain?

93. The base current of a transistor is 5.4 A, and its current gain is 1200. What is the collector current?

Chapter 6

94. What is the bouncing of waves when they encounter a different medium called?

95. Show that the speed of light in vacuum can be expressed in terms of the electric and magnetic constants in the following manner: $c = \dfrac{1}{\epsilon_0 \mu_0}$.

96. The period of a transverse electromagnetic wave is 1μs, what is its frequency? What about its wavelength?

97. How is an electromagnetic field produced?

98. Radar is used to determine distances to various objects by measuring the round-trip time for an echo from the object.

    (i) How far away is the planet Mars if the echo time is 1400 s?

(ii) What is the echo time for a speeding car 100.0 m from a police radar unit?

99. An object of height 10cm is placed in front of a convex mirror of radius 20 cm, 25 cm away from the mirror. Determine the height of the image, how far it is from the mirror, whether it is real or virtual and whether it is upright or inverted.

100. If a mirror produces a real image that is four times as large as the object and the object is located 40cm from the mirror, what is the focal length of the mirror?

101. What is the focal length of a makeup mirror that has a power of 1.50 D?

102. If Apple comes up with an iPhone that has a camera whose zoom lens has an adjustable focal length ranging from 100.0 to 400 mm. What is its range of powers?

103. A clear crystal is immersed in water, and you wish to identify it by finding its index of refraction. You arrange to have a beam of light enter it at an angle of 46^0, and you observe the angle of refraction to be 40^0. What is the index of refraction of the substance and its likely identity.