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Western Provincial Department of Education

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2026

General Certificate of Education (Adv. Level) Examination, 2026

Final Term Test – Grade 13

භෞතික විද්‍යාව II
Physics II

Part B -Essay

01 E II

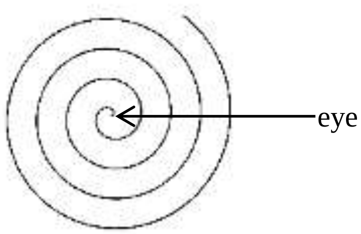
*Answer **four** questions only.*
$(g = 10 \text{ m s}^{-2})$

5. Read the following passage and answer the questions.

On 27 November 2025, a deep depression formed in the Bay of Bengal gradually intensified and developed into the cyclone named "Ditwa". Due to the high temperatures in the Indian Ocean, this depression rapidly intensified into an active cyclone. The cyclone produced winds with speeds close to 120 km h^{-1} and caused heavy rains and flooding conditions in Sri Lanka.

Tropical cyclones are cyclones that occur within the tropical region of the Earth (between the Tropic of Cancer and the Tropic of Capricorn). They are intense spiral storms formed over warm tropical oceans. They contain a low-pressure core and are driven by the Earth's rotation, causing them to rotate anticlockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. A cyclone has three main parts: the Rain Band, the Eye Wall, and the Eye.

The Rain Band is the outermost region of the cyclone. It consists of curved cloud bands moving outward in a spiral pattern and produces thunderstorms and heavy rainfall. These bands may also produce intense rain, strong wind bursts, and tornadoes. The Eye Wall is the region located inside the rain bands. It is the area where the strongest winds occur. The eye wall consists of a ring of towering thunderstorms that produce heavy rain and generally the strongest winds.The Eye of a cyclone is its center. It is a central region characterized by clear skies, warm temperatures, and low atmospheric pressure. The eye is usually calm. It is not a single point but approximately a circular region with a diameter between 30 km and 65 km. After the spiraling wind surrounding the eye passes through the eye region, the wind begins to blow in the opposite direction. The figure below shows how an air mass moves in a spiral path around the eye of a cyclone.



(a)(i) Name the three main parts of a tropical cyclone.

(ii) Draw two diagrams separately to show how an air mass rotates when carried, by a cyclone in the Northern Hemisphere and in the Southern Hemisphere.

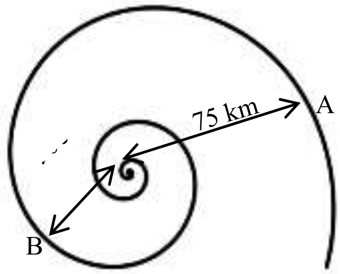
(b)(i) Consider an air mass moving toward the center of a cyclone along a spiral path of decreasing radius. State the two velocity vectors required to describe its motion. (Use standard symbols.).

(ii) If the radial distance from the center of the eye to a point on the spiral path of air mass is r, write the relationship between r and the two velocity vectors mentioned.

(c)(i) A student states that equations of circular motion can be used to describe the motion of an air mass in a cyclone. Is this statement correct? Give reasons for your answer.

(ii) State a principle of physics that can be used to describe the motion of an air mass in a cyclone.

(iii) An air mass moving around the eye of a cyclone along a spiral path has a speed of 120 ms^{-1} at a radial distance of 75 km from the center of the eye (Position A). Find the speed of the same air mass at a radial distance of 30 km from the center of the eye (Position B).



(iv) Using the values obtained in part (iii), explain what happens to the speed of the air mass as it moves from the rain band toward the eye wall.

(d) The Bernoulli equation used to describe the motion of a flow or air can be written as:

$\mathbf{P + \frac{1}{2}dv^2 + hdg = k}$ **(a constant)**. where all the symbols have their usual meanings.

(i) State the conditions under which the Bernoulli's equation is valid.

(ii) Assuming that the region between A and B in the cyclone behaves according to these conditions, calculate the pressure difference between A and B. Assume A and B are at the same horizontal level. density of air 1.2 $kg\,m^{-3}$

(e) A wind generated by the cyclone moved across a region in Sri Lanka with a speed of 126 km h^{-1}.

(i) If this wind passed over a roof of a house having an area of 40 m^2, calculate the lifting force acting on the roof due to the wind. (Assume the air inside the house is stationary.)

(ii) If the roof has a mass of 2000 kg and placed on the walls without using nails, calculate the vertical acceleration acting on the roof.

6. A certain person has a range of vision from 50 cm to 400 cm. The distance from the eye lens to the retina is 2.5 cm. In a normal eye, the range of clear vision is from 25 cm to infinity.

(a) (i) Give reasons why this person's near point is 50 cm and his far point is 400 cm.

(ii) Draw a ray diagram showing how his eye lens forms the image of an object placed 50 cm from his eye lens.

(iii) Calculate the focal length of the eye lens in this situation.

(iv) Show in a ray diagram, how the image is formed when this person looks at an object placed 25 cm away.

(b) The focal length of the eye lens changes appropriately due to the action of the ciliary muscles when observing objects at different distances. But the range within which the focal length can be changed varies from person to person based on age and certain medical conditions.

(i) Calculate the maximum and minimum powers of the eye lens of a normal eye.

(ii) State how the ciliary muscles act when the eye lens operates with maximum power and minimum power in a normal eye.

(iii) Find the maximum focal length that the eye lens of the person mentioned above (in (a)) can attain. What is the power of the lens in this case?

(c) The doctor advises this person to wear spectacles with lenses of power +2 D as a remedy.

(i) When wearing the spectacles, what is the least distance of his distinct vision?

(ii) When wearing the spectacles, this person cannot form the image of an object at infinity on the retina . Explain that with suitable calculations.

(iii) What type of lens should be worn to adjust the far point of this person to that of a healthy eye? Calculate the power of the required lens.

7. When an object falls through a viscous medium, it experiences an upthrust force and a resistive force (viscous frictional force). The upthrust force pushes the object upward, while the resistive force acts opposite to the motion of the object relative to the medium.

(a) (i) For a solid spherical object of radius a , falling through a fluid medium with speed v, write an expression for the resistive force (viscous frictional force) F in terms of radius a, coefficient of viscosity η, and speed v. .

(ii) Show that the expression in part (a) (i) is dimensionally correct.

(iii) State two assumptions used in deriving the expression given in part (a)(i).

(b) Consider a sphere of radius a and density d falling vertically downward with terminal velocity v through a homogeneous liquid of density ρ ($d>\rho$) and coefficient of viscosity η. Derive an expression for the terminal velocity v in terms of a, η, d, ρ and g.

(c) A container is filled with water to a depth of 15 cm. The density of water is 1×10^{3} kg m^{-3} and its coefficient of viscosity is 1×10^{-3} N s m^{-2}. A water- insoluble powder having density 2×10^{3} kg m^{-3} is dispersed onto the water surface. The powder consists of spherical particles of different sizes, and all particles attain terminal velocity immediately after being released.

(i) If the particle with the largest radius deposits at the bottom after 40 minutes from the instant of release (t=0), find the radius (a_1) of that particle in μm. (Take $\sqrt{2}$=1.4)

(ii) If all the particles take 4 hours to deposit at the bottom, find the radius (a_2) of the smallest particle in μm. (Take $\sqrt{3/4}$=0.87)

(iii) On the same axes, sketch the graphs to show the variation of velocities of the largest particle (A) and the smallest particle (B) with time. Label the graphs correctly as A and B.

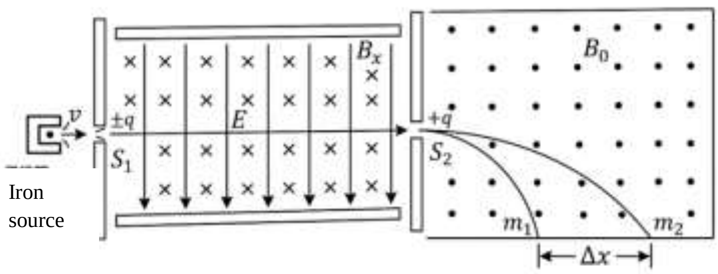
(iv) Assume that the powder added to the container contains an equal numbers of particles with the largest and smallest radii and that they are initially evenly distributed , what fraction of the smaller particles are deposited in the layer after the particles with the largest radius have been deposited?

(d) If a liquid having a coefficient of viscosity greater than that of water were added to the same container, how would the motion of the powder particles deviate from the previous situation. Assume the powder remains insoluble in the new liquid as well.

8. The figure shows a mass spectrometer used to measure the ratio between the mass and charge of charged particles accurately. Initially, an iron source produces a beam of positive ions with charge +q and mass m. These ions enter to a region known as the velocity selector through slit S_1.

The velocity selector consists of a pair of parallel metal plates separated by a distance d. By applying a potential difference V across the plates, a uniform electric field is produced. In the same region, a uniform magnetic field of flux density B, perpendicular to the electric field, is also present. The forces exerted on the ions by these two fields, act in opposite directions. Only ions that travel in a straight line without deviation within the velocity selector emerge through slit S_2.

In the second stage, these ions enter an analyzer chamber containing a uniform magnetic field B_o. Since the magnetic force acts perpendicular to the ion velocity, the ions move along semicircular paths and finally strike a detector plate. After the ion strikes the detector plate it produces a spot.



(a) (i) Write expressions for the electric force F_e acting on the ion due to the electric field in the velocity selector, and for the magnetic force F_b due to the magnetic field.

(ii) Briefly explain the relationship that must exist between F_e and F_b for an ion to exit through slit S_2 without deviation.

(iii) If the separation between the plates in the velocity selector is d and the potential difference across the plates is V, show that the speed of the particle is $v = \frac{V}{Bd}$.

(iv) The separation between the plates in the velocity selector is 10 cm, and a potential difference of 10,000 V is applied across them. If the magnetic flux density is 0.5 T, calculate the velocity of the emerging ions.

(v) If the speed of an ion is greater than the value calculated above, will it emerge through slit S_2? Give reasons.

(b) (i) Show that the magnetic force acts as the centripetal force inside the analyzer chamber, and derive the expression for the radius of the path as $r = \frac{mv}{qB_0}$.

(ii) Describe the relationship between the radius r of the path and the mass m of the particle.

(iii) If the magnetic flux density in the analyzer chamber (B_o) is 0.5 T, the charge of the ion is 1.6×10^{-19} C, and the mass of it is 4.0×10^{-26} kg, calculate the radius (r_1) of its path.

(iv) The mass of second isotope is 10% greater than the first isotope. Calculate the radius (r_2) of its path.

(v) Find the straight-line distance (Δx) between the spots where these two isotopes strike on the detector plate, in millimeters.

(c) (i) Obtain an expression for the time t taken by an ion to enter the analyzer chamber and strike the detector plate, in terms of m, q, and B_o.

(ii) Does this time t depend on the velocity of the particle? Explain.

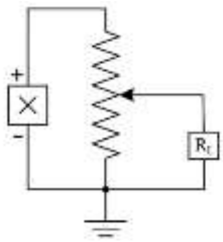
(iii) If only the potential difference V in the velocity selector is doubled, what happens to the separation (Δx) between the spots on the detector plate?

(iv) If a magnetic field is applied parallel to the velocity of the particle inside the analyzer chamber, what type of path would the particle follow?

(v) The mass of neutral atoms cannot be measured by this instrument. Explain the reason using electric forces and magnetic forces.

9. Answer either Part (A) or Part (B) only.

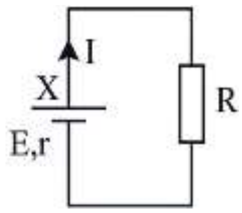
Part (A)



(*a*) A load R_L is connected in parallel with a variable resistor having a sliding contact, to a DC supply (X) of voltage V. The voltage across the load R_L must be increased continuously from zero to the maximum value V.

(i) Using two graphs, show the variation of voltage across R_L with respect to the supply voltage V for a fixed resistor and for a filament lamp

(ii) Explain why the two graphs drawn above are different.



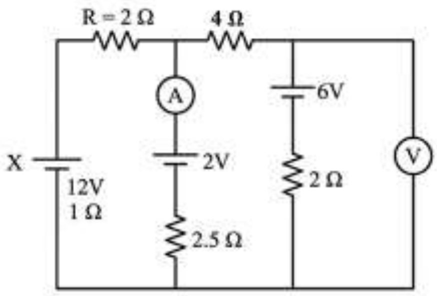
(b) A source X with an electromotive force E and internal resistance r is connected to an external resistor of resistance R. The total energy supplied to the circuit in time t is E_T .

(i) Define the electromotive force (e.m.f.).

(ii) Using the above definition, determine the unit of e.m.f E.

(iii) Write an expression for the power (P_X) supplied by source X, in terms of e.m.f. E and current I.

(iv) Derive an expression for the total energy E_T supplied to the circuit in time t, in terms of E, r, R and t .



(c) A circuit prepared by connecting the source X and the resistor R is shown in the figure. A is an ammeter with internal resistance 0.5 Ω, and V is an voltmeter with infinite resistance.

(i) Calculate the readings of the ammeter A and voltmeter V using the Kirchhoff's laws.

(ii) Find the amount of energy supplied by source X in 10 s.

Part (B)

(*a*) The operational amplifier shown in Figure (1) has saturation voltages of +15 V and -15 V. Its open-loop voltage gain is (A) = 10^5 .

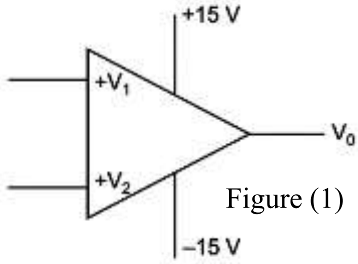


Figure (1)

(i) If V_1 = 5.0002 V and V_2 = 5.0000 V, calculate the output voltage (V_0) .

(ii) Find the minimum input voltage difference ($V_1 - V_2$) in μV, required for the output to saturate.

(b) In the circuit shown in Figure (2), point P is connected to the non-inverting input of the operational amplifier. The inverting input is connected to a fixed voltage of 6V. The supply voltage is 12V.

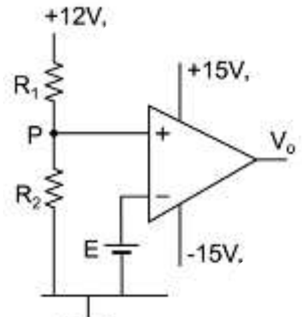


Figure (2)

(i) If R_1 = 10 kΩ and R_2 = 20 kΩ, calculate the voltage (V_p) at point P.

(ii) Write down the output voltage (V_0) in case (i) above .

(iii) To get the output to be -15V, by what minimum value should the resistance R_1 be increased?

(c) Now, a 5V Zener diode (Vz = 5V) and a resistor are connected to the output as shown in Figure (3). The inverting input is connected to 4V , while the non-inverting input receives an input signal varying from 0V to 8V .

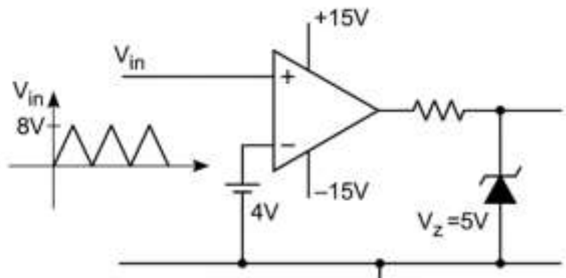


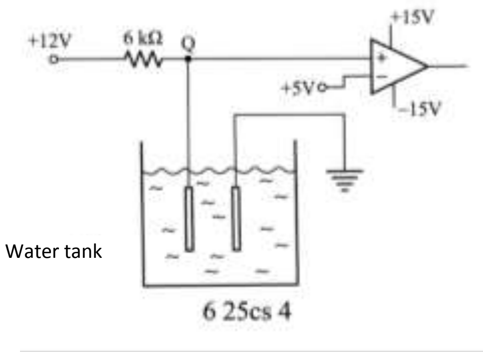
Figure (3)

(i) Write the output voltage (V_0) when the input voltage is 2V.

(ii) Write the output voltage (V_0) when the input voltage is 8V.

(iii) Sketch the output waveform as the input varies from 0V to 8V, and mark the maximum values.

(d) A system for checking the water-level of a water tank is shown in Figure (4). When water is present, the resistance between the electrodes is 3 kΩ. In the absence of water , the circuit between the electrodes remains disconnected. The series resistor is R = 6 kΩ and the supply voltage is 12V. The mid-point (Q) is connected to the non-inverting input of the operational amplifier, while the inverting input is connected to 5V .



Fogure (4)

(i) Calculate the voltage (V_Q) at point Q when water is present.

(ii) Calculate the voltage (V_Q) at point Q, when water is absent .

(iii) Write down the output voltage when the tank is full of water.

10. Answer either Part (A) or Part (B) only.

Part (A)

Global climate change is strongly influenced by the El Niño and La Niña phenomena. El Niño is a process of simultaneous increases in temperature around the Pacific Ocean. During an El Niño event, the surface water temperature in the eastern Pacific Ocean rises by about 2°C than normal temperature. Due to this high temperature, a low-pressure region forms on the ocean surface. Water vapor is brought to that low-pressure region from high-pressure region and through that law pressure increases to high-pressure. The sea winds formed during this process do not reduce the temperature of the ocean surface, instead, the ocean water becomes warmer and spreads further. It releases more heat into the atmosphere as the warm water remains close to the ocean surface and creates warmer, more humid air. As a result the Earth's surface temperature increases.

La Niña is the opposite condition. In this case, the temperature around the Eastern Pacific Ocean will decrease and cold conditions will be experienced. During La Niña, accumulated water vapor and rapid cooling of ocean regions under high pressure cause heavy rainfall. Here the temperatures decrease by about 3–5°C than the normal ocean temperature. El Niño can also cause changes in wind patterns, increased evaporation from oceans and land, faster coastal erosion, and threats to glacier regions.

(a) Why does the Earth's surface temperature increase during an El Niño event?

(b) During an El Niño event, consider a region of the eastern Pacific Ocean with an area of $1.2 \times 10^{12}\ m^2$, where the water up to a depth of 50 m becomes warmer.(Specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$ Density of seawater = 1020 kg m^{-3})

(i) If an object of mass m has specific heat capacity C, write an equation for the heat energy Q absorbed when its temperature increases by $\Delta\theta$.

(ii) Find the total mass of the heated water.

(iii) Calculate the extra thermal energy required to heat this mass of water.

(c) Assume that 40% of the heat absorbed by the water is used for evaporation

(i) Calculate the mass of water evaporated from the ocean surface.(Latent heat of vaporization of water 2.4×10^6 J kg^{-1}) (The equation $Q = mL$ can be used for this)

(ii) Find the thickness of the evaporated water layer that evaporates from ocean surface.

(iii) When temperature rises, increase the evaporation from the ocean to the atmosphere. Explain in physics.

(d) Without El Niño, the temperature in coastal area of Sri Lanka is 27°C. A water of mass $10 \times 10^3\ kg$ absorbs $8.4 \times 10^7\ J$ of heat energy during El Niño.

(i) Calculate the increase in temperature of the water.

(ii) Find the coastal temperature of Sri Lanka during El Niño

(e) During El Niño, the amplitude of sea waves increases from 1.2 m to 1.8 m.

(i) If the energy of water waves without El Niño is E_1 and during El Niño is E_2, find the ratio $\frac{E_1}{E_2}$.

(ii) Explain how water waves increases coastal erosion during El Niño .

(f) A person of mass 75 kg produces energy at a rate of 100 W while walking in a normal day. 75% of this energy is converted into heat. Ignore heat loss during the respiratory process.

(i) Calculate the amount of heat produced while walking for 15 minutes.

(ii) How much water mass would evaporate when that heat released?

(Latent heat of vaporization of water at body temperature = $2.4 \times 10^6\, J\, kg^{-1}$) ($Q = mL$ equation can be used here.)

(iii) If this heat is not removed from the body, calculate the increase in body temperature after 15 minutes. (The mean specific heat capacity of body is $3600\, J\, kg^{-1}\, ℃^{-1}$)

(iv) Why outdoor sports and activities are discouraged during El Niño conditions. Explain using the answers you got above.

Part (B)

When radiation falls on a metal surface, electrons are emitted from that surface. This phenomenon is known as the photoelectric effect. Using Planck's theory of black body radiation, Albert Einstein further developed the explanation of the photoelectric effect.

(a) A radiation of frequency (f) is incident on a photosensitive surface.

(i) If the maximum kinetic energy of emitted photoelectrons is K_{max}, the work function of the material is ϕ, Planck's constant is h and frequency is f write down the Einstein's photoelectric equation .

(ii) What is meant by the work function?

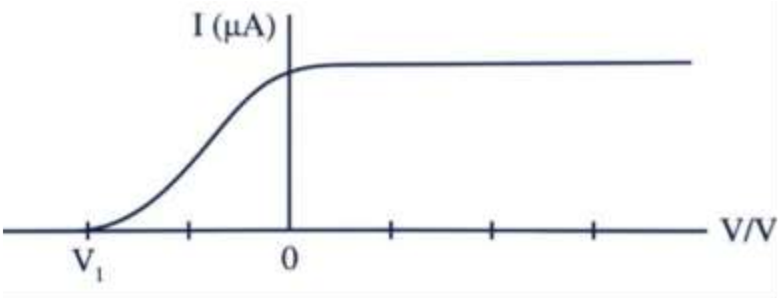
(iii) Write down an expression for the work function ϕ , in terms of the threshold wavelength $\lambda_{0,}$ and h. (velocity of incident radiation c = $3 \times 10^8 ms^{-1}$)

iv) If the work function of the photosensitive material (ϕ) is 4.24 eV, calculate the threshold wavelength in nm. (h=6.63×10^{-34} J s, Charge of electron e= 1.6×10^{-19} C)

v) If the wavelength of the incident radiation is 240 nm, calculate the maximum kinetic energy K_{max} of the emitted photo electrons in joules(J) .

vi) Calculate the potential at which the photocurrent becomes zero. Write down the special name given to that potential.

(b) As in (a) above, the graph of the variation of photocurrent (I) with potential difference (V), while keeping the intensity and frequency of incident radiation are constant is given below.



Copy the above graph to your answer sheet and sketch the variation of (I) with (V) for the following cases, labeling them as (i) and (ii).

(i) When the intensity of incident light is doubled while keeping the frequency constant.
(ii) When the frequency is reduced to half while the intensity of light remains constant.

(c) X-rays are produced by the reverse process of the photoelectric effect. X-rays are a type of electromagnetic waves and occupy the wavelength range from 0.005 nm to 0.1 nm in the electromagnetic spectrum.

(i) X-rays are divided into two main categories based on energy, penetrating power and wavelength. Name these two categories
(ii) Explain how the two categories named in part (i) vary with the properties of energy, penetrating power, and wavelength.
(iii) State two applications of X-rays in two different fields.

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