**2005 Leaving Cert Physics Solutions (Higher Level)**

1

In an experiment to verify the principle of conservation of momentum, a body A was set in motion with a constant

velocity. It was then allowed to collide with a second body B, which was initially at rest and the bodies moved off together at constant velocity.

The following data was recorded.

Mass of body A = 520.1 g

Mass of body B = 490.0 g

Distance travelled by A for 0.2 s before the collision = 10.1 cm

Distance travelled by A and B together for 0.2 s after the collision = 5.1 cm



1. **Draw a diagram of the apparatus used in the experiment.**

See diagram

1. **Describe how the time interval of 0.2 s was measured.**

It corresponded to 10 intervals on the ticker-tape.

1. **Using the data calculate the velocity of the body A before and after the collision.**

Velocity before: *v = s/t =* 0.101/0.2

*v* = 0.505 m s-1  ≈ 0.51 m s-1

Velocity after: *v* = 0.051/0.2

*v* = 0.255 m s-1 ≈ 0.26 m s-1

1. **Show how the experiment verifies the principle of conservation of momentum.**

Momentum before

*p* = *mv* = (0.5201)(0.505) = 0.263 ≈ 0.26 kg m s-1

Momentum after

*p* = *mv = (*0.5201 + 0.4900)(0.255)

*p* = 0.258 ≈ 0.26 kg m s-1

Momentum before ≈ momentum after

1. **How were the effects of friction and gravity minimised in the experiment?**

Friction: sloped runway // oil wheels or clean track

Gravity: horizontal track // frictional force equal and // tilt track so that trolley moves with constant velocity

2

In an experiment to measure the specific latent heat of vaporisation of water, cool water was placed in an insulated copper calorimeter.

Dry steam was added to the calorimeter. The following data was recorded.

Mass of calorimeter = 50.5 g

Mass of calorimeter + water = 91.2 g

Initial temperature of water = 10 oC

Temperature of steam = 100 oC

Mass of calorimeter + water + steam = 92.3 g

Final temperature of water = 25 oC

1. Calculate a value for the specific latent heat of vaporisation of water.

mslw + mscwΔθs = mwcwΔθw+ mcccΔθc

Δθs = 75 0C and Δθw (= Δθc) = 15 0C

 (0.0011) lw + (0.0011)(4200)(75) = (0.0407)(4200)(15) + (0.0505)(390)(15)

[(0.0011) lw + 346.5 = 2564.1 + 295.425]

lw = 2.28 × 106 J kg-1

1. **Why was dry steam used?**

Calculations assume that only steam is added, not water.

1. **How was the steam dried?**

Use a steam trap / insulated delivery tube / sloped delivery tube / allow steam to issue freely initially

1. **A thermometer with a low heat capacity was used to ensure accuracy. Explain why.**

It absorbs little heat from system in calorimeter and calculations assume that no energy is transferred to the thermometer.

3

 In an experiment to verify Snell’s law, a student measured the angle of incidence *i* and the angle of refraction *r* for a ray of light entering a substance. This was repeated for different values of the angle of incidence. The following data was recorded.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *i*/degrees | 20 | 30 | 40 | 50 | 60 | 70 |
| *r*/degrees | 14 | 19 | 26 | 30 | 36 | 40 |

1. **Describe, with the aid of a diagram, how the student obtained the angle of refraction.**

See diagram, plus ray-box.

Mark the position of the incident and exit rays and also the outline of the block.

Remove the block then measure the angle between the refracted ray and the normal using a protractor.

1. **Draw a suitable graph on graph paper and explain how your graph verifies Snell’s law.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| sin i | 0.34 | 0.50 | 0.64 | 0.77 | 0.87 | 0.94 |
| sin r | 0.24 | 0.33 | 0.44 | 0.50 | 0.59 | 0.64 |



1. **From your graph, calculate the refractive index of the substance.**

Refractive index = slope = y2 – y1 / x2 – x1  n = 1.49

1. **The smallest angle of incidence chosen was 200.**

**Why would smaller values lead to a less accurate result?**

There would be a greater percentage error associated with measuring smaller angles.

4

A student investigated the variation of the current *I* flowing through a filament bulb for a range of different values of potential difference *V*.

1. **Draw a suitable circuit diagram used by the student.**

See diagram

1. **Describe how the student varied the potential difference.**

By adjusting the voltage on the power supply.

1. **The student drew a graph, as shown, using data recorded in the experiment.**

**With reference to the graph, explain why the current is not proportional to the potential difference.**

Because the graph is not a straight line.

1. With reference to the graph, calculate the change in resistance of the filament bulb as the potential difference increases from 1 V to 5 V.

At 1 V: *R = V/I =* 1/0.028 = 35.7 Ω

At 5 V: *R* = (5/0.091) = 54.9 Ω

Change in resistance (= 54.9 – 35.7) = 19.2 Ω

1. **Give a reason why the resistance of the filament bulb changes.**

As current increases the temperature of filament increases, therefore the filament gets hotter and it gets more difficult for electrons to pass through due to increased vibration of the metal atoms.

**2005 Question 5**

* 1. **A container contains 5.0 kg of water. If the area of the base of the container is 0.5 m2. Calculate the pressure at the base of the container due to the water. (acceleration due to gravity = 9.8 m s–2)**

$Pressure=\frac{force}{area}$

The force corresponds to the weight *mg*. $P=\frac{mg}{area}$ $P=\frac{(5.0)(9.8)}{0.5}$  P = 98 Pa

* 1. **State Boyle’s law*.***

Pressure is inversely proportional to volume for a fixed mass of gas at constant temperature

* 1. **What is the thermometric property of a thermocouple?**

emf

* 1. **An object O is placed 30 cm in front of a concave mirror of focal length 10 cm. How far from the mirror is the image formed?**

$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$ $\frac{1}{10}=\frac{1}{30}+\frac{1}{v}$ $\frac{1}{10}-\frac{1}{30}=\frac{1}{v}$ $\frac{2}{30}=\frac{1}{v}$  *v* = 15 cm = 0.15 m

* 1. **A capacitor of capacitance 100 μF is charged to a potential difference of 20 V. What is the energy stored in the capacitor?**

E = ½CV2 E = ½(100 × 10-6)(20)2   E = 0.02 J

* 1. **Draw a sketch of the magnetic field due to a long straight current-carrying conductor.**

See diagram

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* 1. **A pear-shaped conductor is placed on an insulated stand as shown.**

**Copy the diagram and show how the charge is distributed over the conductor when it is positively charged.**

Arrange the charges so that they are more concentrated at the pointed end.

* 1. **Explain why high voltages are used in the transmission of electrical energy.**

High voltages result in smaller currents, therefore less energy is lost as heat.

* 1. **How are electrons produced in an X-ray tube?**

Thermionic emission occurs at the heated cathode.

* 1. **Name the fundamental force of nature that holds the nucleus together.**

The strong nuclear force.

**2005 Question 6**

1. **Define angular velocity.**

Angular velocity is the rate of change of displacement with respect to time.

1. **Define centripetal force.**

The force - acting in towards the centre - required to keep an object moving in a circle is called centripetal force.

1. **State Newton’s Universal Law of Gravitation.**

Newton’s Law of Gravitation states that any two point masses in the universe attract each other with a force that is directly proportional to the product of their masses, and inversely proportional to the square of the distance between them.

1. **Derive the relationship between the period of the satellite, the mass of Saturn and the radius of the orbit.**

Centripetal force = gravitational force

$\frac{mv^{2}}{r}=\frac{Gm\_{1}m\_{2}}{d^{2}}$

 v2

⇒  ⇒

Equating both equations for *v*2 we get

1. **The period of the satellite is 380 hours. Calculate the radius of the satellite’s orbit around Saturn.**

$T^{2}=\frac{4π^{2}R^{3}}{GM}$ $R^{3}=\frac{GMT^{2}}{4π^{2}}$

T = (380)(60)(60) = 1.37 × 106 seconds $R^{3}=\frac{(6.7×10^{-11})(6.0×10^{24})(1.37×10^{6})^{2}}{4π^{2}}$

R = 1.2 × 109 m

1. **How long does it take the signal to travel to earth?**

$speed=\frac{distance}{time}$ $time=\frac{distance}{speed}$ $time=\frac{1.2 ×10^{12}}{3.0×10^{8}}$ t = 4000 s
*{note that radio waves travel at the speed of light}*

1. **It is noticed that the frequency of the received radio signal changes as the satellite orbits Saturn. Explain why.**

As the satellite orbits Saturn it is at times moving away from us and at other times moving towards us while all the time emitting radio waves. So from the Doppler effect the frequency will seem to change also.

**2005 Question 7**

1. **Name the two phenomena that occur when the light passes through the pair of narrow slits.**

Diffraction and interference

1. **A pattern is formed on the screen. Explain how the pattern is formed.**

The slits act as sources of two coherent waves which overlap to give areas of constructive interference (bright lines) and destructive interference (dark lines).

1. **What is the effect on the pattern when the wavelength of the light is increased?**

*{nλ = d Sin θ*

*If λ increases then the left hand side of this equation gets bigger, therefore the right hand side must get bigger.*

*‘d’ is fixed (we haven’t changed the diffraction grating), so the only thing which can increase on the right hand side is Sin θ. If Sin θ increases then θ increases.}*

Answer: The pattern of bright images gets more spread out.

1. **What is the effect on the pattern when the distance between the slits is increased?**

*{nλ = d Sin θ*

*In this case both values on the left hand side can’t change, so the total on the left is constant. Therefore the total on the right must remain constant. The only way for this value to remain constant if the distance between the slits (d) goes up is if Sin θ goes down.}*

Answer: The pattern becomes less spread out.

1. **Describe an experiment to demonstrate that sound is also a wave motion.**
* Walking slowly from X to Y, you will notice the loudness of the sound increasing and decreasing at regular intervals.

This is because sound waves from the two speakers will interfere both constructively and destructively, along the path XY.

1. **Explain the difference between longitudinal and transverse waves.**

Longitudinal waves: the direction of the vibrations is parallel to the direction of propagation of the wave.

Transverse wave: the direction of the vibrations is perpendicular to the direction of the wave.

1. **Describe an experiment to demonstrate that light waves are transverse waves.**

Light source and two pieces of polaroid as shown.

Rotate one polaroid relative to the other and note that the light intensity increases and decreases

Only transverse waves can be polarised, so light is a transverse wave.

**2005 Question 8**

1. **Distinguish between radioactivity and fission.**

Nuclear fission is the break-up of a large nucleus into two smaller nuclei with the release of energy and neutrons.

Nuclear fusion is the combining of two small nuclei to form one large nucleus with the release of energy.

1. **Give an application of radioactivity.**

Smoke detectors, carbon dating, tracing leaks, cancer treatment, sterilising, etc.

1. **Give an application of fission.**

Generating electrical energy, bombs

1. **Radioactivity causes ionisation in materials. What is ionisation?**

Ionisation occurs when a neutral atom loses or gains an electron.

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1. **Describe an experiment to demonstrate the ionising effect of radioactivity.**

Procedure: Bring a radioactive source close to the cap of a charged Gold Leaf Electroscope

Observation: Leaves collapse

Conclusion: The charge on the G.L.E. became neutralised by the ionised air.

1. **Write an equation to represent the decay of cobalt−60.**

$$\rightarrow $$

1. **Calculate the decay constant of cobalt−60.**

$T\_{1/2}=\frac{ln2}{λ}$ $λ=\frac{ln2}{T\_{1/2}}$ $λ=\frac{0.693}{1.66 × 10^{8}}$  λ = 4.18 × 10-9 s-1

1. **Calculate the rate of decay of a sample of cobalt−60 when it has 2.5 × 1021 atoms.**

Rate of decay = Activity = λN

Rate of decay = (4.18 × 10-9)( 2.5 × 1021) = 1.04 × 1013 Bq

**2005 Question 9**

1. **Define potential difference.**

Potential difference is the work done in bringing unit charge from one point to another.

1. **Define resistance.**

Resistance of a conductor is the ratio of the potential difference across it to the current passing through it.

1. **Derive an expression for the effective resistance of the two resistors in terms of *R1* and *R2*.**

For currents in parallel: ITotal = I1 + I2

But I = $\frac{V}{R}$ (Ohm’s Law)

⇒ $\frac{V}{R\_{T}}$ = $\frac{V}{R\_{1}}$ + $\frac{V}{R\_{2}}$

We can now cancel the *V*’s because the voltage is the same for resistors in parallel

⇒ $\frac{1}{R\_{T}}$ = $\frac{1}{R\_{1}}$ + $\frac{1}{R\_{2}}$

1. **At room temperature calculate the total resistance of the circuit.**

For the two resistors in parallel$\frac{1}{R\_{parallel}}$ = $\frac{1}{R\_{1}}$ + $\frac{1}{R\_{2}}$ $\frac{1}{R\_{p}}$ = $\frac{1}{500}$ + $\frac{1}{750}$*Rp* = 300 Ω

*RTot al* = 300 + 300 = 600 Ω



1. **At room temperature calculate the current flowing through the 750 Ω resistor.**

$I\_{Total}=\frac{V\_{Total}}{R\_{Total}}$ = $\frac{6}{600}$ = 0.01 A

V300 = I300R300 = (0.01)(300) = 3 V

The voltage across the resistors in parallel corresponds to the total voltage minus the voltage across the 300 Ω resistor.

 Vp = 6 – 3 = 3 V.

Now for the 750 Ω resistor we know both the voltage and the resistance: $I\_{750}=\frac{3}{750}$ = .004 A = 4 mA

1. **As the temperature of the room increases, explain why the resistance of the thermistor decreases.**

The thermal energy absorbed by the thermistor releases lots of electrons from the individual atoms which now become available for conduction.

*{This effect is much greater than the increased resistance due to the greater thermal agitation of the atoms.}*

1. **As the temperature of the room increases, explain why the potential at A increases.**

*{In this context the phrase ‘potential at a point’ means the potential between that the point and the negative end of the battery. There was no way for you to know this- it certainly wasn’t on the syllabus☹}*

The resistance of thermistor (and 750 Ω combination) decreases.

Therefore the potential difference across thermistor and 750 Ω combination decreases.

The voltage across the resistors in parallel corresponds to the total voltage minus the voltage across the 300 Ω resistor.

Therefore the voltage across the 300 Ω resistor increases.

Therefore the potential at *A* increases.

**2005 Question 10**

1. **Define electric field strength*.***

Electric field strength is defined as force per unit charge.

1. **State Coulomb’s law of force between electric charges.**

The force between two charges is proportional to the product of the charges and inversely proportional to the square of the distance between them.

1. **Why is Coulomb’s law an example of an inverse square law?**

Because the force is inversely proportional to the distance squared.

1. **Give two differences between the gravitational force and the electrostatic force between two electrons.**

Gravitational force is much smaller than the electrostatic force.

Gravitational force is attractive, electrostatic force (between two electrons) is repulsive.

1. **Describe an experiment to show an electric field pattern.**
2. Place two electrodes in a petri-dish.
3. Pour some oil into the petri-dish and sprinkle on some semolina powder.
4. Connect a high voltage source (about 2,000 volts) to the metal electrodes.

Result: The semolina lines up in the direction of the field, showing the electric field.

1. **Calculate the electric field strength at the point B, which is 10 mm from an electron.**

$E=\frac{Q}{4πεd^{2}}$ $E=\frac{1.6 ×10^{-19}}{4π(8.9×10^{-12})(0.01)^{2}}$ E = 1.4 × 10-5 N C-1

1. **What is the direction of the electric field strength at B?**

Towards the electron / to the right

1. **A charge of 5 μC is placed at B. Calculate the electrostatic force exerted on this charge.**

$E=\frac{F}{Q}$ *F = Eq*  *F =* (1.4 × 10-5)(5 × 10-6)  *F* = 7.2 × 10-11 N

Towards the electron

**2005 Question 11 (a)**

1. **What is the structure of an alpha particle?**

An alpha particle is identical to a helium nucleus (2 protons and 2 neutrons).

1. **What conclusion did he form about the structure of the atom?**

The atom was mostly empty space with a dense positively-charged core and with negatively-charged electrons in orbit at discrete levels around it.

1. **High voltages can be used to accelerate alpha particles and protons but not neutrons.Explain why.**

Alpha particles and protons are charged, neutrons are not.

1. **Copy and complete the following nuclear equation for this reaction.**

 ** +  → ** + K.E.

1. **Give an advantage of circular accelerators over linear accelerators.**

Circular accelerators result in progressively increasing levels of energy and occupy much less space than an equivalent linear accelerator.

1. **Explain why new particles are produced.**

The kinetic energy of the two protons gets converted into mass.

1. **List the six flavours of quark.**

Up, down, strange, charm, top and bottom.

1. **Give the quark composition of the proton.**

Up, up, down.

**2005 Question12 (a)**

1. **State the principle of conservation of energy.**

Energy cannot be created or destroyed but it can only be changed from one form to another .

1. **What is the maximum kinetic energy of the ball as it falls?**

Potential energy at the top = kinetic energy at the bottom

*mgh =* (0.6)(9.8)(3.05) = 17.9 J

kinetic energy at the bottom = 17.9 J

1. **What happens to the energy lost by the ball?**

It changes into sound and heat.

1. **Calculate the height of the first bounce of the ball.**

*{The ball had 17.9 Joules of energy when it hit the ground.*

*If it lost 6 J in the bounce then it must have 17.9 – 6= 11.9 J as it starts to rise back up. This is its intitial kinetic energy for this stage.*

*But from principal of conservation of energy, kinetic energy at the bottom = potential energy at the top}*

11.9 = *mghnew* $h\_{new}=\frac{11.9}{(0.600)(9.8)}$ *hnew* = 2.02 m

**2005 Question 12 (b)**

1. **Define magnetic flux.**

Magnetic flux is defined as the product of magnetic flux density and area.

1. **State Faraday’s law of electromagnetic induction.**

The size of the induced emf is proportional to the rate of change of magnetic flux.

1. **A square coil of side 5 cm lies perpendicular to a magnetic field of flux density 4.0 T. The coil consists of 200 turns of wire. What is the magnetic flux cutting the coil?**

*A =* (0.05)2 = 0.0025

Φ *= BA*  *=* (4)(0.0025) = 0.01 Wb

1. **Calculate the magnitude of the average e.m.f. induced in the coil while it is being rotated.**

*{this diagram wasn’t in the original question but it might be useful to get a picture of what’s happening.*

*When the red coil is vertical there are no magnetic flux lines passing through the coil (the area is 0). But when the coil is horizontal as shown then the magnetic flux is a maximum because the area is a maximum (flux = BA)}*

Induced emf = $\left(N\right)[\frac{final flux – initial flux}{time taken}]$

E = $\left(200\right)[\frac{0.01 – 0}{0.2}]$ E= 10 V

**2005 Question 12 (c)**

1. **Give two other factors that affect the frequency of a stretched string.**

Tension and mass per unit length

1. **What is the frequency of vibration of the string?**

*{The distance from one node to another in a standing wave corresponds to half a wavelength.}*

0.65=$\frac{λ}{2}$ λ = (2)(0.65) = 1.3 m

*v = f*λ  $f=\frac{v}{λ}$ $f=\frac{500}{1.3}$  *f* = 384.6 Hz

1. **Draw a diagram of the string when it vibrates at its second harmonic.**



1. **What is the frequency of the second harmonic?**

f2nd = 2(f1st )= 769.2 Hz

**2005 Question 12 (d)**

1. **What is the photoelectric effect?**

The photoelectric effect is the emission of electrons from the surface of a metal when light of suitable frequency shines on it.

1. **Write down an expression for Einstein’s photoelectric law.**

h*f* = ɸ + ½*mv2*

1. **Summarise Einstein’s explanation of the photoelectric effect.**

Light is composed of packets (or bundles) of energy which he called photons.

All of energy from one photon is given to one electron.

Energy of the photon must be equal to or greater than the work function of the metal for the photoelectric effect to occur.

Any excess energy appears as kinetic energy of the electron.

1. **Give one application of the photoelectric effect.**

Sound track in film, photography, counters, photocell, burglar alarm, automatic doors, etc.