**2008 Leaving Cert Physics Solutions (Higher Level)**

1

A student investigated the relationship between the period and the length of a simple pendulum. The student measured the length l of the pendulum.

The pendulum was then allowed to swing through a small angle and the time t for 30 oscillations was measured.

This procedure was repeated for different values of the length of the pendulum.

The student recorded the following data:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| l /cm  | 40.0  | 50.0  | 60.0  | 70.0  | 80.0  | 90.0  | 100.0  |
| t /s  | 38.4  | 42.6  | 47.4  | 51.6  | 54.6  | 57.9  | 60.0  |
| Time for 1 swing/ s |  |  |  |  |  |  |  |
| t2/ s2 |  |  |  |  |  |  |  |
| l /m  | 0.4 | 0.5 | 0.6  | 0.7  | 0.8  | 0.9 | 1.0  |

1. **Why did the student measure the time for 30 oscillations instead of measuring the time for one?**

To reduce percentage error in measuring the periodic time.

1. **How did the student ensure that the length of the pendulum remained constant when the pendulum was swinging?**

Use an inextensible string, string suspended at fixed point (e.g. split cork or two coins)

1. **Using the recorded data draw a suitable graph to show the relationship between the period and the length of a simple pendulum.**



1. **What is this relationship?**

t2 is proportional to l

1. **Use your graph to calculate the acceleration due to gravity.**

Slope = 0.25 (ms–2) [range: 0.24 – 0.25 m s–2]

*g* = 9.72 m s–2 [range: 9.4 – 9.9 m s–2]

2

In an experiment to measure the specific latent heat of fusion of ice, warm water was placed in a copper calorimeter.

Dried, melting ice was added to the warm water and the following data was recorded.

Mass of calorimeter 60.5 g

Mass of calorimeter + water 118.8 g

Temperature of warm water 30.5 oC

Mass of ice 15.1 g

Temperature of water after adding ice 10.2 oC

1. **Explain why warm water was used.**

To speed up the melting of the ice / in order to melt a larger mass of ice / (concept of) balancing energy losses before and after the experiment.

1. **Why was dried ice used?**

To remove any water/melted ice // melted ice would have already gained latent heat //so that only ice is added // so that no water is added

1. **Why was melting ice used?**

Melting ice is at 0 oC.

1. **Describe how the mass of the ice was found.**

Final mass of calorimeter + contents minus mass of calorimeter + water.

1. **What should be the approximate room temperature to minimise experimental error?**

20 0C / midway between initial and final temperatures (of the water in the calorimeter)

1. **Calculate the energy lost by the calorimeter and the warm water.**

{energy lost = } (*mc*Δθ )cal + (*mc*Δθ )warm water

= (0.0605)(390)(20.3) + (0.0583)(4200)(20.3)

= 5449.6365 / 5449.6 J

1. **Calculate the specific latent heat of fusion of ice.**

{Energy gained by ice and by melted ice =}

(*ml*)ice + (*mc*Δθ )melted ice / (0.0151)*l* + (0.0151)(4200)(10.2) / 0.0151 *l* + 646.884

(equate:) 0.0151 *l* + 646.884 = 5449.6365

*l* = 3.181 × 105 ≈ 3.2 × 105 J kg–1

3

In an experiment to measure the wavelength of monochromatic light, a diffraction pattern was produced using a diffraction grating with 500 lines per mm. The angle between the first order images was measured. This was repeated for the second and the third order images.

The table shows the recorded data:

|  |  |  |
| --- | --- | --- |
| Angle between first order images  | Angle between second order images  | Angle between third order images  |
| 34.20 | 71.60 | 121.60 |

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

See diagram. Plus metre stick

1. **Explain how the first order images were identified.**

Nearest on either side of the central (zero order) image.

1. **Describe how the angle between the first order images was measured.**

Measure x between 1st order images

Measure D from screen to grating

θ = tan-1 (x/D)

1. **Use the data to calculate the wavelength of the monochromatic light.**

Use nλ = d sinθ



4

A student investigated the variation of the resistance R of a metallic conductor with its temperature θ.

The student recorded the following data.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| θ/oC  | 20  | 30  | 40  | 50  | 60  | 70  | 80  |
| R/Ω  | 4.6  | 4.9  | 5.1  | 5.4  | 5.6  | 5.9  | 6.1  |

1. **Describe, with the aid of a labelled diagram, how the data was obtained.**

The resistance was read from the ohmmeter, the temperature was read from the thermometer and the readings were varied using the heat source.

1. **Draw a suitable graph to show the relationship between the resistance of the metal conductor and its temperature.**



1. **Use your graph to estimate the resistance of the metal conductor at a temperature of –20 oC.**

Continue (extrapolate) the graph on the left hand side and then read off the resistance value that corresponds to the temperature of – 20 0C.

*R* = 3.6 Ω

1. **Use your graph to estimate the change in resistance for a temperature increase of 80 oC.**

 y-intercept value ≈ 4.12 Ω  change in resistance ≈ 2 Ω

1. **Use your graph to explain why the relationship between the resistance of a metallic conductor and its temperature is linear.** (This was mistakenly termed ‘non-linear’ in the original exam paper).

A straight line is obtained.

**2008 Question 5**

1. **State the law of flotation.**

When a body floats in a liquid its weight is equals the weight of fluid displaced.

1. **The head of a thumbtack has an area of 500 mm2. Its point has an area of 0.3 mm2. The pressure exerted at the head of the thumbtack is 12 Pa. What is the pressure exerted at the point of the thumbtack?**

The key to this is the fact that while the pressure changes (as a result of the area over which the force is exerted changing), the force itself is constant.

Force = (Pressure)(Area)

At the head: F = Pressure × Area  F = (12)(500 × 10-6)  F = 6.0 × 10-3 N

At the point:  = = 2.0 × 104 Pa

1. **What is the relationship between the frequency of a vibrating stretched string and its length?**

Frequency is proportional to

1. **Why does diffraction not occur when light passes through a window?**

For diffraction to occur the slit width needs to be approximately the same as the wavelength of the wave, and a window is too wide (relative to wavelength of light).

1. **Why is a fluorescent tube an efficient source of light?**

Most of the electrical energy is converted to light energy.

1. **What is the force exerted on an electron when it is in an electric field of strength 5 N C–1?**

 F = Eq  F = (5)(1.6 × 10–19)  F = 8.0 × 10–19 N

1. **What are the charge carriers when an electric current (i) passes through a semiconductor; (ii) passes through an electrolyte?**
2. electrons and (positive) holes (ii) ions
3. **Give two ways of deflecting a beam of electrons.**

By means of an electric field and a magnetic field.

1. **Name an instrument used to detect radioactivity. What is the principle of operation of this instrument?**

A Geiger-Muller tube. Ionisation.

1. **The existence of the neutrino was proposed in 1930 but it was not detected until 1956. Give two reasons why it is difficult to detect a neutrino.**

No charge and very small mass.

**2008 Question 6**

1. **State Newton’s law of universal 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. **What type of force is required to keep the ISS in orbit?**

Gravity

1. **What is the direction of this force?**

Towards the centre of the orbit / inwards / towards the earth

1. **Calculate the acceleration due to gravity at a point 400 km above the surface of the earth.**

*{note that ‘d’ is the distance from a point 400,000 m above the earth to the* ***centre*** *of the earth}*

  = mg    g = 8.6 m s-2

1. **An astronaut in the ISS appears weightless. Explain why.**

He is in a state of free-fall (the force of gravity cannot be felt).

1. **Derive the relationship between the period of the ISS, the radius of its orbit and the mass of the earth.**

Centripetal force = gravitational force

 v2

⇒  ⇒

Equating both equations for *v*2 we get

1. **Calculate the period of an orbit of the ISS.**

 T2 = 3.1347 × 107  T = 5.6 × 103 s

1. **After an orbit, the ISS will be above a different point on the earth’s surface. Explain why.**

The ISS has a different period to that of the earth’s rotation (it is not in geostationary orbit).

1. **How many times does an astronaut on the ISS see the sun rise in a 24 hour period?**

(24 ÷ 1.56 + 1) = 16 ( sunrises).

**2008 Question 7**

1. **Define resistivity and give its unit of measurement.**

Resistivityis defined as the resistance of a cube of material of side 1 m.

1. **What is the difference between convection and radiation as a means of heat transfer?**

Convection requires a medium, radiation does not.

1. **Calculate the resistivity of nichrome.**

A = πr2 = π (1.1 × 10-3)2 = 3.80 × 10-6 m2

 ρ = 1.14 × 10-6 Ω m.

1. **Calculate the heat generated by the toaster in 2 minutes if it has an efficiency of 96%.**

Heat generated = power × time = (1050)(120) = 1.26 × 105 J

96% of 1.26 × 105 = 1.21 × 105 J

1. **The toaster has exposed metal parts. How is the risk of electrocution minimised?**

The metal parts are earthed.

1. **Explain, in terms of movement of electrons, why light is emitted when a metal is heated.**

Electrons gain energy and jump to higher energy state. Then when they fall back down they emit electromagnetic radiation in the form of light.

**2008 Question 8**

1. **What is electromagnetic induction?**

Electromagnetic Induction occurs when an emf is induced in a coil due to a changing magnetic flux.

1. **State the laws of electromagnetic induction.**

Faraday’s Law states that the size of the induced emf is proportional to the rate of change of flux.

Lenz’s Law states that the direction of the induced emf is always such as to oppose the change producing it.

1. **Explain why the amplitude of the swings decreases rapidly.**

An emf is induced in the copper because is its experiencing a changing magnetic flux.

This produces a current.

This current has a magnetic field associated with it which opposes the motion of the magnet.

1. **What is the main energy conversion that takes place as the magnet slows down?**

Kinetic (or potential) to electrical (or heat).



1. **How long does it take the loop to completely enter the field?**

*{A diagram helps to visualise what’s happening here.}*

 = 0.01 seconds

1. **What is the magnetic flux cutting the loop when it is completely in the magnetic field?**

Φ = BA = (8)(0.05)2 = 0.02 webers
*{the area in this case corresponds to the area of the loop, which is a square of side 0.05 m}*

1. **What is the average emf induced in the loop as it enters the magnetic field?**

*{The area the flux lines are passing through is 0 when the coil is outside (so magnetic flux is 0). But when the coil is fully inserted then the flux is a maximum (BA)}*

Induced emf = = = 2 Volts

**2008 Question 9**

1. **What is meant by refraction of light?**

Refraction is the bending of light as it passes from one medium to another (of different refractive index).

1. **State Snell’s law of refraction.**

The ratio of the sin of the angle of incidence to the sin of the angle of refraction is a constant.

1. **Calculate how near an object can be placed in front of the eye and still be in focus.**

The maximum power of the eye system = 64 m–1. This allows us to calculate *f*.

 = = 0.0156 m *f* = 1.56 cm

The retina is 2.0 cm from the lens system. The image is formed on the retina and the distance from lens system to retina corresponds to the image distance. So *v* = 2.0 cm

 *u* = 7.14 cm

1. **Calculate the maximum power of the internal lens.**

Ptotal = P1 + P2 PTotal = Pfixed lens + Pvariable lens  64 = 38 + P2  P2 = 26 m-1

1. **Calculate the refractive index of the cornea.**

  = 1.33

1. **Draw a diagram to show the path of a ray of light as it passes from water of refractive index 1.33 into the cornea.**

Both media have the same refractive index so the light ray doesn’t bend.

1. **When underwater why does the cornea not act as a lens?**

Because the cornea has the same refractive index as water, therefore light doesn’t bend as it passes from water into the cornea.

1. **What is the maximum power of the eye when underwater?**

 The maximum power of the eye is 64 m–1, but this includes the focusing power of the cornea (which is 38 m-1). But the cornea no longer acts as a lens when underwater, so all that’s left is the internal lens, which as we have calculated above has a maximum power of 26 m–1.

1. **Why do objects appear blurred when underwater?**

Because the internal lens by itself is not powerful enough to focus light onto the retina.

1. **Explain how wearing goggles allows objects to be seen clearly.**

Because light which hits the cornea is now entering the cornea *from air* and therefore *will* refract so the cornea will once again act as a lens.

**2008 Question 10 (a)**

Baryons and mesons are made up of quarks and experience the four fundamental forces of nature.

1. **List the four fundamental forces and state the range of each one.**

Strong (short range), Weak (short range), Gravitational (infinite range), Electromagnetic (infinite range).

1. **Name the three positively charged quarks.**

Up, top, charm.

1. **What is the difference in the quark composition of a baryon and a meson?**

Baryon: three quarks

Meson: one quark and one antiquark

1. **What is the quark composition of the proton?**

Up, up, down

1. **In a circular accelerator, two protons, each with a kinetic energy of 1 GeV, travelling in opposite directions, collide. After the collision two protons and three pions are emitted.**

**What is the net charge of the three pions? Justify your answer.**

The total charge beforehand was +2 (due to the two protons).

Therefore the total charge afterwards must be +2 (due to conservation of charge).

But there are also 2 protons afterwards, so they account for the +2 by themselves.

So the net charge (or all other particles added together) must therefore be zero.

1. **Calculate the combined kinetic energy of the particles after the collision.**

P+ + P+ + kinetic energy (of protons) →P+ + P+ + π + π + π + kinetic energy (of pions)

*So in effect the kinetic energy beforehand went into producing 3 pions, and whatever was left over became the kinetic energy of those pions.*

*So to find this kinetic energy we need to subtract the energy required to make the 3 pions away from the original kinetic energy.*

Kinetic energy beforehand = 2 GeV = (2 × 109) (1.6 × 10-19) = 3.2 × 10-10 Joules

Energy required to produce 3 pions: E = 3*mc*2 = 3(2.4842 × 10–28)( 2.9979 × 108)2

= 6.6981 × 10–11 Joules

Kinetic energy after collision = (3.2 × 10-10) - (6.6981 × 10–11) = 2.53 × 10–10 J

1. **Calculate the maximum number of pions that *could* have been created during the collision.**

Kinetic energy beforehand = 3.2 × 10-10 Joules

Energy required to produce *1* pion = *mc*2 = (2.4842 × 10–28)( 2.9979 × 108)2 = 2.2327 × 10–11 Joules

Number of pions = = 14.35

So the maximum number that *could* have been created is 14 pions.

**2008 Question 11**

1. **The SI unit is named in honour of Lord Kelvin. What is the temperature of the boiling point of water in kelvin?**

273.15 + 100 = 373.15 K

1. **Define the newton, the unit of force.**

A force of 1 N gives a mass of 1 kg an acceleration of 1 m s-2.

1. **Using Newton’s laws of motion, calculate the change in momentum of the ball.**

From Newton II: Force ∝ rate of change of momentum

 {but k=1}  (F)(t) = mv – mu

 (F)(t) = (9 × 103)( 0.6 × 10-3) = 5.4 kg m s-1 = (mv – mu) = change in momentum

1. **Nam three different electromagnetic radiations.**

x-rays, microwaves, ultra-violet etc.

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

The photoelectric effect is the emission of electrons from a metal due to light of a suitable frequency falling upon it.

1. **Why was the quantum theory of light revolutionary?**

Light has a particle nature (as well as a wave nature)

1. **What is the energy of a photon of this radiation?**

*E = hf*

E = (6.6 × 10–34)( 3.3 × 1014) = 2.18 × 10–19 J.

1. **100 MJ of energy are released in a nuclear reaction. Calculate the loss of mass during the reaction.**

E = mc2  = = 1.11 × 10-9 kg.

**2008 Question 12 (a)**

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

This states that energy cannot be created or destroyed but can only be converted from one form to another.

1. **Draw a velocity-time graph to illustrate the athlete’s horizontal motion.**

See diagram

1. **Use your graph to calculate the distance travelled by the athlete before jumping.**

Distance (s) = area under curve = area 1 (triangle) + area 2 (rectangle)

 s = ½ (3)(9.2) + 2 (9.2) = 13.8 + 18.4 = 32.2 m

1. **What is the maximum height above the ground that the athlete can raise his centre of gravity?**

Kinetic energy at the bottom = Potential energy at the top

½ mv2 = mgh

 = = 4.32 m

But this is the height his centre of gravity rises.

His centre of gravity was already 1.1 m above the ground, so in total his centre of gravity will now be: 4.32 + 1.1 = 5.42 m above the ground.

**2008 Question 12 (b)**

1. **On what does (i) the quality, (ii) the loudness, of a musical note depend?**

Quality depends on the number of overtones their relative strengths.

Loudness depends on amplitude of the wave.

1. **What is the Doppler Effect?**

The doppler effectis the apparent change in the frequency of a wave due to the relative motion between the source of the wave and the observer.

1. **A rally car travelling at 55 m s–1 approaches a stationary observer. As the car passes, its engine is emitting a note with a pitch of 1520 Hz. What is the change in pitch observed as the car moves away** *{i.e. between when it passes and as it moves away}*?

****  ****  f1 = 1308.35 Hz

  change in frequency = 1520 – 1308.35 = 211.65 Hz.

1. **Give an application of the Doppler Effect.**

Calculate speeds of stars or galaxies, speed traps.

**2008 Question 12 (c)**

1. **Write a nuclear reaction to represent the reaction.**



1. **Why are the neutrons slowed down?**

Only relatively slow-moving neutrons cause fission.

1. **How are they slowed down?**

They collide with the molecules in the moderator.

1. **Give one positive and one negative environmental impact of fission reactors.**

Positive: no CO2 emissions / no greenhouse gases / no gases to result in acid rain / less dependence on fossil fuels.

Negative: radioactive waste / potential for major accidents etc.

**2008 Question 12 (d)**

1. **Define capacitance.**

The capacitance of a conductor is the ratio of the charge on the conductor to its potential.

1. **Describe how an electroscope can be charged by induction.**
2. Bring a negatively charge rod near the electroscope
3. Keeping the charged rod in place, earth the electroscope by touching the cap with your finger.
4. Remove your finger, then *and only then* remove the rod.

The conductor will now be positively charged.

1. **How would you demonstrate that the capacitance of a parallel plate capacitor depends on the distance between its plates?**

Connect the two parallel plates to a digital multi-meter (DMM) set to read capacitance.
Note the capacitance.

Increase the distance between them – note that the capacitance decreases.