**2007 Leaving Cert Physics Solutions (Higher Level)**

1

A student investigated the laws of equilibrium for a set of co-planar forces acting on a metre stick.

The student found that the centre of gravity of the metre stick was at the 50.4 cm mark and its weight was 1.2 N.

1. **How did the student find the centre of gravity?**

By hanging the metre stick on a thread support and adjusting the position of the thread until the metre stick remained horizontal.

1. **How did the student find the weight, of the metre stick?**

By putting it on an electronic balance.

1. **Why is the centre of gravity of the metre stick not at the 50.0 cm mark?**

The material is not of perfectly uniform density.

1. **The student applied vertical forces to the metre stick and adjusted them until the metre stick was in equilibrium.**

**How did the student know that the metre stick was in equilibrium?**

The metre stick was at rest.

The student recorded the following data.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| position on metre stick/cm | 11.5 | 26.2 | 38.3 | 70.4 | 80.2 |
| magnitude of force/N | 2.0 | 4.5 | 3.0 | 5.7 | 4.0 |
| direction of force | down | up | down | up | down |

1. **Calculate the net force acting on the metre stick.**

Fup = 4.5 + 5.7 = 10.2 N and Fdown = 2 + 3 +1.2 +4 = 10.2 N

 net force = 0

1. **Calculate the total clockwise moment about a vertical axis of the metre stick.**

(through zero) = 2(0.115) + 3(0.383) +1.2(0.504) +4.0(0.802) **=** 0.23+1.149+0.6048+3.208 **=** 5.2 N m

1. **Calculate the total anti-clockwise moment about a vertical axis of the metre stick.**

(through zero) = 4.5(0.262) +5.7(0.704) **=** 5.1918 N m **=** 5.2 N

1. **Use these results to verify the laws of equilibrium**

Fup = Fdown

Total clockwise moments = Total anti-clockwise moments

2

|  |
| --- |
| mass of calorimeter 55.7 g |
| mass of calorimeter + water 101.2 g |
| mass of copper + calorimeter + water 131.4 g |
| initial temperature of water 16.5 oC |
| temperature of hot copper 99.5 oC |
| final temperature of water 21.0 oC |

The specific heat capacity of water was found by adding hot copper to water in a copper calorimeter. The following data was recorded.

1. **Describe how the copper was heated and how its temperature was measured.**

It was heated using a hot-plate and temperature was measured using a thermometer.

1. **Using the data, calculate the energy lost by the hot copper**

E = m c Δθ

E = (3.02 × 10-2)(390)(78.5) = 924.6 J

1. **Using the data, calculate the specific heat capacity of water.**

Heat lost by hot copper = heat gained by calorimeter + water

924.57 = (0.0557)(390)(4.5) + (0.0455)(cw)(4.5)

**** 924.57 = 97.75 + 0.2048 cw

cw = 4.04 ×103 J kg-1 K-1

1. **Give two precautions that were taken to minimise heat loss to the surroundings.**

Insulate calorimeter /use lid /transfer copper pieces quickly / use cold water (below room temperature) / polish calorimeter / low heat capacity thermometer

1. **Explain why adding a larger mass of copper would improve the accuracy of the experiment.**

A larger mass of copper would result in a larger temperature change and therefore smaller percentage error .

**2007 Question 3**

In an experiment to measure the focal length of a concave mirror, an approximate value for the focal length was found. The image distance v was then found for a range of values of the object distance u.

The following data was recorded.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| u/cm | 15.0 | 20.0 | 25.0 | 30.0 | 35.0  | 40.0 |
| v/cm | 60.5 | 30.0 | 23.0 | 20.5 | 18.0 | 16.5 |

1. **How was an approximate value for the focal length found?**

An image of a distant object was focused on a screen.

Measure the distance from the screen to the mirror.

1. **What was the advantage of finding the approximate value for the focal length?**

To avoid placing object inside f during the experiment) which would have meant that the image couldn’t be formed on the screen.

1. **Describe, with the aid of a labelled diagram, how the position of the image was found.**

Apparatus: object, concave mirror, screen

Adjust the position of the the screen until a clear image of the crosswire is obtained.

1. **Calculate the focal length of the concave mirror by drawing a suitable graph based on the recorded data.**

The question shouldn’t have specified the drawing of a graph as it wasn’t specified on the syllabus. As a result marking scheme was adjusted and you could get 15 marks out of 18 by using the normal approach.

For the record, if you do graph the data then where the line cuts either axis corresponds to 1/f, so invert to get f. Do this for both axes and get the average.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| u/cm | 15.0 | 20.0 | 25.0 | 30.0 | 35.0  | 40.0 |
| v/cm | 60.5 | 30.0 | 23.0 | 20.5 | 18.0 | 16.5 |
| 1/u  |  |  |  |  |  |  |
| 1/v |  |  |  |  |  |  |

Calculate 1/*u* and 1/*v* values

Label axes

Plot at least five points

Straight line

Extrapolate to cut axis (or axes)

Read axis (or axes) value = 0.085

Focal length = 12.0 cm

For use of data table rather than graphical work:

Correct formula

Correct substitution

One correct *f* value

*f average*

4

The following is part of a student’s report of an experiment to investigate of the variation of current I with potential difference V for a semiconductor diode.

I put the diode in forward bias as shown in the circuit diagram. I increased the potential difference across the diode until a current flowed. I measured the current flowing for different values of the potential difference.

I recorded the following data.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| V/V | 0.60 | 0.64 | 0.68 | 0.72 | 0.76 | 0.80 |
| I /mA | 2 | 4 | 10 | 18 | 35 | 120 |



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

See diagram

1. **How did the student vary and measure the potential difference?**

Adjust rheostat / potential divider /variable power supply unit.

To measure p.d. a voltmeter was used as shown in the diagram.

1. **Draw a graph to show how the current varies with the potential difference.**

****

1. **Estimate from your graph the junction voltage of the diode.**

Junction voltage = 0.60 ↔0.78 V (very difficult to be more specific).

1. **The student then put the diode in reverse bias and repeated the experiment.**

**What changes did the student make to the initial circuit?**

Reverse connections to the power supply, replace mA with μA.

1. **Draw a sketch of the graph obtained for the diode in reverse bias.**

Correct shape (i.e. showing little or no current as *V* is increased negatively and maybe indicating a breakdown.

**2007 Question 5**

1. **State Archimedes’ principle.**

When an object is immersed in a fluid, the upthrust it experiences is equal to the weight of the displaced fluid.

1. **Why is a filament light bulb not an efficient source of light?**

Almost all of the energy is given off as heat.

1. **Why does the temperature of an athlete reduce when she perspires?**

As the water evaporates it changes state. As a result it takes a lot of heat energy (from the body).

1. **How is infra-red radiation detected?**

Temperature sensor / photographic film.

1. **The refractive index of a liquid is 1.35, what is the critical angle of the liquid?**

$n\_{g}=\frac{1}{\sin(C)}$ $\sin(C)=\frac{1}{n\_{g}}$ $\sin(C)=\frac{1}{1.35}$ $C=sin^{-1}\frac{1}{1.35}$  C = 47.80

1. **Calculate the energy stored in a 5 μF capacitor when a potential difference of 20 V is applied to it.**

E = ½ CV2  = ½ (5 x 10-6)(20)2 = 1.0 x 10-3 J

1. **Why does a magnet that is free to rotate point towards the North?**

*{What we refer to as the magnetic north pole is actually the south pole of the earth’s magnetic field.}*

The north end of a magnet points towards the north because it is actually pointing towards a south pole of the earth’s magnetic field.

1. **State the principle on which the definition of the ampere is based.**

A current-carrying conductor in a magnetic field experiences a force.

1. **How are electrons accelerated in a cathode ray tube?**

By a large potential difference.

1. **A kaon consists of a strange quark and an up anti-quark. What type of hadron is a kaon?**

It is a meson.

**2007 Question 6**

1. **State Hooke’s law.**

For a stretched string the restoring force is proportional to the extension.



1. **Calculate its spring constant.**

At equilibrium position: force down= force up

mg = k(extension)

 (0.30)(9.8) = (k)(0.085)

k = 34.6 N m-1

1. **Derive the relationship between the acceleration of the sphere and its displacement from the fixed point.**

F = - ks  ma = - ks  a = - $\frac{k}{m}s$  a α -s  a = - k s

1. **Why does the sphere oscillate with simple harmonic motion?**

We can see from the mathematical relationship above that the acceleration is proportional to displacement (and they are acting in opposite directions). This equation is consistent with the general equation for SHM.

1. **Calculate the period of oscillation of the sphere.**

From above: ω2 = $\frac{k}{m}$  ω2 = $\frac{34.6}{0.3}$ ω = 10.7

T = $\frac{2π}{ω}$ = $\frac{2π}{10.7}$ = 0.58 ≈ 0.6  T = 0.6 s

1. **Calculate the maximum acceleration of the sphere.**

*a* = *-*ω2s so acceleration is proportional to displacement. So acceleration will be a maximum when displacement is a maximum.

 Maximum displacement (*s*) is the same as the amplitude.

In this context the amplitude is the distance between release point and equilibrium position.

= 0.310 – 0.285 = 0.025 m.

 *a* = *-*ω2s  *amax* = - (10.7)2(0.025)  *amax* = (-) 2.89 m s-2

1. **Calculate the length of the spring when the acceleration of the sphere is zero.**

This occurs at equilibrium position *l* = 0.285 m

**2007 Question 7**

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. **Explain, with the aid of labelled diagrams, how this phenomenon occurs.**The circles represent the crests of sound waves emitted from the source. In this case the source is moving to the right while emitting the waves.The result is that:
2. Ahead of the moving source, the crests are closer together than crests from a stationary source would be. This means that the wavelength is smaller and the frequency is greater.
3. Behind the moving source, the crests are further apart than crests from the stationery source would be.
4. This means the wavelengths are greater and therefore the frequency is less.
5. **Describe how an emission line spectrum is produced.**

When the gas is heated the electrons in the gas are move up to higher orbital level and as they fall back down they emitelectromagnetic radiation of a specific frequency.

1. **Is the star approaching the earth? Justify your answer.**

No

The wavelength has increased therefore it must be moving away.

1. **Calculate the frequency of the red line in the star’s spectrum**

f’ = $\frac{c}{λ’}$ f’ = $\frac{3×10^{8}}{720×10^{-9}}$  f’ = 4.17 × 1014 Hz

f = $\frac{c}{λ}$ f = $\frac{3×10^{8}}{656×10^{-9}}$  f = 4.57 × 1014 Hz

1. **Calculate the speed of the moving star**

f’ = 4.17 × 1014 Hz

f = 4.57 ×1014 Hz

c = 3 ×108 m s-1

The star is moving away from the earth, therefore we use ‘plus’ in the formula:



$$4.17×10^{14}[\left(3×10^{8})+u\right)]=1.371×10^{23}$$

$$1.251×10^{23}+(4.17×10^{14})(u)=1.371×10^{23}$$

$$(4.17×10^{14})(u)=1.371×10^{23}-1.251×10^{23}$$

$$(4.17×10^{14})(u)=1.2×10^{22}$$

u = 2.88 ×107 m s−1

**2007 Question 8**

1. **Define electric field strength and give its unit of measurement.**

Electric field strength at a point is the force per unit charge at that point.

The unit is the N C-1

1. **Describe how an electric field pattern may be demonstrated in the laboratory.**
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.
5. Result: The semolina lines up in the direction of the field, showing the electric field.
6. **Calculate the electric field strength at a point 7 cm from the dome.**

*{the distance in this case corresponds to the distance from a point 0.07 m (7 cm) outside to dome to the centre of the dome (charge is spread all over the dome but we can treat it as a point situated in the middle). Therefore d = 0.07 + 0.15 = 0.22 m}*

E = E = *E* = 7.39 x 1011 N C-1

1. **Calculate the electrostatic force exerted on the 5 μC point charge.**

*F* = *Eq*

*F* = (7.39 × 1011)(5 × 10-6) *F* = 3.69 × 106 N

1. **All the charge resides on the surface of a Van de Graff generator’s dome. Explain why.**

Like charges repel and the charges are a maximum distance apart on the outside surface of dome.

1. **Describe an experiment to demonstrate that total charge resides on the outside of a conductor.**
2. ****Charge the conductor (a metal can will do fine).
3. Using a proof plane, touch the *inside* of the can and bring it up to the gold leaf electroscope (GLE).
4. Notice that there is no deflection.
5. Touch the proof plane off the *outside* of the can and bring it up to the GLE.
6. Notice that there is a deflection.
7. Conclusion: charge resides on outside only
8. **Give an application of this effect.**

Electrostatic shielding / co-axial cable / TV (signal) cable / to protect persons or equipment, enclose them in hollow conductors /Faraday cages (there is no electric field inside a closed conductor), etc.

**2007 Question 9**

1. **Define resistance.**

The resistance of a conductor is the ratio of the potential difference across it to the current flowing through it.

1. **Define resistivity.**

The resistivity of a material is defined as the resistance of a cube of material of side 1 m.

1. **Calculate the resistance of the nichrome wire**

$\frac{R\_{1}}{R\_{2}}=\frac{l\_{1}}{l\_{2}}$ $\frac{R}{20}=\frac{282}{718}$ R = 7.86 Ω

1. **Calculate the resistivity of nichrome**

A=πr2 = (π)(.11×10-3)2 = 3.801×10-8 m2

$ρ=\frac{RA}{l}$ $ρ=\frac{(7.855)(3.801×10^{-8})}{0.220}$ ρ = 1.36 × 10-6 Ω m

1. **Sketch a graph to show the relationship between the temperature and the resistance of the nichrome wire as its temperature is increased.**

Axes labelled R and T (or θ)

Correct linear graph with intercept showing *R* greater than zero.



1. **What happens to the resistance of the wire as its temperature falls below 0oC?**

*R* decreases

1. **What happens to the resistance of the wire as its length is increased?**

*R* increases

1. **What happens to the resistance of the wire if its diameter is increased?**

*R* decreases

1. **Name another device, apart from a metre bridge, that can be used to measure resistance.**

Ohmmeter / wheatstone bridge /multimeter.

1. **Give one advantage and one disadvantage of using this device instead of a metre bridge.**

Ohmmeter:

Advantage: compact, portable, faster method

Disadvantage: less accurate

**2007 Question 10 (a)**



1. **Draw a labelled diagram to show how Cockcroft and Walton accelerated the protons.**

See diagram.

1. **What is the velocity of a proton when it is accelerated from rest through a potential difference of 700 kV?**

$$QV=\frac{1}{2}mv^{2}$$

$v^{2}=\frac{2QV}{m}$ = $\frac{(2)(1.6022×10^{-19})(7×10^{5})}{1.6727×10^{-27})}$ = 1.16 × 107 m s-1

1. **Write a nuclear equation to represent the disintegration of a lithium nucleus when bombarded with a proton.**

$$+$\rightarrow +$

(accept α for *He* )

1. **Calculate the energy released in this disintegration.**

Mass beforehand (mass of reactants) = 1.1646 × 10-26 + 1.6726 × 10-27 = 1.33186 × 10-26 kg

Mass afterwards (mass of products) = 2(6.6443 × 10-27) = 1.32886 × 10-26 kg

Loss in mass = 1.33186 × 10-26 kg - 1.32886 × 10-26 kg = 3.00 × 10-29 kg

*E* = *mc2* or = (3.00 × 10-29)(9 × 1016) = *E* = 2.7 × 10-12 J

1. **Compare the properties of an electron with that of a positron.**

Both have equal mass / charges equal / charges opposite in sign

1. **What happens when an electron meets a positron?**

Pair annihilation occurs.

1. **In beta decay it appeared that momentum was not conserved.**

**How did Fermi’s theory of radioactive decay resolve this?**

Fermi (and Pauli) realised that another particle must be responsible for the missing momentum, which they called the neutrino.

**2007 Question 11**

* 1. **What is nuclear fission?**

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

* 1. **How much energy is generated worldwide every minute by nuclear power today?**

*“Nuclear power generation could increase from three hundred gigawatts today . . .”*

Three hundred gigawatts = 300 billion W = 300 × 109 Joules per second

= (300 × 109)(60) Joules in one minute = or 1.8 × 1013 J every minute

* 1. **At present, why is a fission reactor a more viable source of energy than a fusion reactor?**

Fission can be more easily controlled / easier to initiate reaction or *vice versa*

* 1. **Deuterium is an isotope of hydrogen, what is an isotope?**

Isotopes are atoms which have the same atomic number but different mass numbers.

* 1. **What is the function of a moderator in a fission reactor?**

To slow down fast neutrons to facilitate fission.

* 1. **Why is silicon a semiconductor?**

It has a resistivity between that of a conductor and an insulator.

* 1. **If the solar constant is 1400 W m–2, what is the maximum power generated by the solar cells?**

1400 watts in one square metre so in 20 square metres the power would be: (1400 × 20) = 28000 W

But it’s only 20% efficient. 20% of 28000 = 5600 W

* 1. **What is the source of the sun’s energy?**

Nuclear fusion

**2007 Question 12 (a)**

1. **What is friction?**

Friction is a force which opposes the relative motion between two objects.

1. A car of mass 750 kg is travelling east on a level road. Its engine exerts a constant force of 2.0 kN causing the car to accelerate at 1.2 m s–2 until it reaches a speed of 25 m s–1.

**Calculate the net force acting on the car.**

Fnet = ma Fnet = (750)(1.2) Fnet = 900 N East.

1. **Calculate the force of friction acting on the car.**

*F*net = *Fbig – Fsmall F*net = *Fcar - Ffriction* 900 = 2000 - *Ffriction*   *Ffriction* = 1100 N west

1. **If the engine is then turned off, calculate how far the car will travel before coming to rest?**

Friction causes deceleration: a = F ÷ m

Here we will use *vuast*, but we need to work out the acceleration *a*.

The only force acting on the car at this stage is the friction force.

$a=\frac{F}{m}$ $a=\frac{1100}{750}$ *a* = 1.47 ms-2

*v*2 = *u*2 + 2*as*

0 = 252 +2(-1.47) *s* *s* = 213 m

*{Note that* ***a*** *is negative because in this context it represents a deceleration.}*

**2007 Question 12 (b)**

1. **Define sound intensity.**

 Sound Intensity is defined as power per unit area.

1. **What is the sound intensity at a distance of 3 m from the loudspeaker?**

*The sound energy from the speaker dissipates in 3 dimensions, similar to an expanding (spherical balloon). The area therefore corresponds to the surface area which the energy is passing through.*

*Surface area of sphere = 4πr2*

$Sound Intensity=\frac{25 ×10^{-3} }{4π(3)^{2}}$ S.I. = 2.21 × 10-4 W m-2

1. **What is the change in the sound intensity?**

$Sound Intensity=\frac{50 ×10^{-3} }{4π(3)^{2}}$ S.I. = 4.42 × 10-4 W m-2 The change is 2.21 × 10-4 W m-2

1. **What is the change in the sound intensity level?**

*{Note: Doubling the Sound Intensity increases the Sound Intensity Level by 3dB}*

Answer: Sound intensity level increased by 3 dB

1. **How is this taken into account when measuring sound intensity levels?**

There is an adapted scale which takes this into account called the *decibel adapted* (dBA) scale

**2007 Question 12 (c)**

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

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

1. **Describe an experiment to demonstrate Faraday’s law.**

Move the magnet in and out of the coil slowly and note a slight deflection in the galvanometer.

Move the magnet quickly and note a greater deflection.

1. **What is the effect on the current flowing in the circuit?**

Current is reduced

1. **Justify your answer**

An emf is induced in coil. This induced emf (known as back emf) has an associated current which which opposes the initial current (from Lenz’s law).

**2007 Question 12 (d)**

1. **Explain the term half-life.**

Time for half the radioactive nuclei in a sample to decay

1. **Write a nuclear equation to represent the decay of carbon-14.**

$$\rightarrow $$

1. **An ancient wooden cup from an archaeological site has an activity of 2.1 Bq.**

**The corresponding activity for newly cut wood is 8.4 Bq.**

**If the half-life of carbon-14 is 5730 years, estimate the age of the cup.**

It takes one half-life for the activity to decrease from 8.4 Bq to 4.2 Bq.

It takes another half-life for the activity to decrease from 4.2 Bq to 2.1 Bq.

It therefore requires two half-lives to go from 8.4 Bq to 2.1 Bq

Each half-life is 5730 years. Therefore the total time that has passed is 11,460 years.

The cup is 11,460 years old.

1. **Name an instrument used to measure the activity of a sample.**

Geiger Muller tube.

1. **What is the principle of operation of this instrument?**

The gas in the tube is ionised by radioactive particles.