**2004 Leaving Cert Physics Solutions (Higher Level)**

1

In an experiment to measure the acceleration due to gravity *g* by a free fall method, a student measured the time *t* for an object to fall from rest through a distance *s*.

This procedure was repeated for a series of values of the distance *s.*

The table shows the data recorded by the student.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *s*/cm | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| *t*/ms | 244 | 291 | 325 | 342 | 371 | 409 | 420 |

1. **Describe, with the aid of a diagram, how the student obtained the data.** The clock starts as sphere is released and stops when the sphere hits the trapdoor.

S is the distance from solenoid to trap-door.

Record distance *s* and the time *t*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *s*/cm | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| *t*/ms | 244 | 291 | 325 | 342 | 371 | 409 | 420 |
| *t2*  /s2 | 0.060 | 0.085 | 0.106 | 0.117 | 0.138 | 0.167 | 0.176 |

1. **Calculate a value for *g* by drawing a suitable graph.**

Calculation of *t2*(at least five correct values)

Axes *s* and *t2* labelled

At least five points correctly plotted

Straight line with good fit

Method for slope

Correct substitution

*g* = 10.0 ± 0.2 m s−2

1. **Give two precautions that should be taken to ensure a more accurate result.**

measure from bottom of sphere; avoid parallax error; for each value of *s* take several values for *t* / min *t* reference; ensure no external force (e.g. draughts, etc.) acts on sphere (during release); adjust ‘sensitivity’ of trap door; adjust ‘sensitivity’ of electromagnet (using paper between sphere and core); use large values for *s* (to reduce % error); use millisecond timer

2

In an experiment to measure the wavelength of monochromatic light, the angle θ between a central bright image (*n* = 0) and the first and second order images to the left and the right was measured*.*

A diffraction grating with 500 lines per mm was used.

The table shows the recorded data.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *n* | 2 | 1 | 0 | 1 | 2 |
| θ /degrees | 36.2 | 17.1 | 0 | 17.2 | 36.3 |

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

See diagram, plus metre stick.

Measure distance *x* from central fringe for *n* = ±1, ±2

Measure distance *D* from grating to screen and calculate θ in each case using tan θ = x/D

1. **Use all of the data to calculate a value for the wavelength of the light.**

*n*λ = *d* sinθ

*d = 1/500000  d* = 2 × 10-6

*n*=1, λL= 588.1 nm, λR= 591.4 nm

*n*=2, λL= 590.6 nm, λR= 592.0 nm

Calculated average wavelength **=** 590 nm.

1. **Explain how using a diffraction grating with 100 lines per mm leads to a less accurate result.**

It would result in a smaller value for θ which would mean larger percentage errors.

1. **The values for the angles on the left of the central image are smaller than the corresponding ones on the right. Suggest a possible reason for this.**

The grating may not be perpendicular to the incident light

3

A student investigated the variation of the fundamental frequency *f* of a stretched string with its length *l*.

1. **Draw a labelled diagram of the apparatus used in this experiment. Indicate on the diagram the points between which the length of the wire was measured.**



The student drew a graph, as shown, using the data recorded in the experiment, to illustrate the relationship between the fundamental frequency of the string and its length.

1. **State this relationship and explain how the graph verifies it.**

f is proportional to 1/l.

A straight line through the origin verifies this.

The student then investigated the variation of the fundamental frequency *f* of the stretched string with its tension *T*.

The length was kept constant throughout this investigation.

1. **How was the tension measured?**

Using a newton-balance / pan with weights / suspended weights

1. **What relationship did the student discover?**

Frequency is proportional to √Tension.

1. **Why was it necessary to keep the length constant?**

Because length is a third variable and you can only investigate the relationship between two variables at a time.

1. **How did the student know that the string was vibrating at its fundamental frequency?**

The paper rider on the string falls off.

4

 The following is part of a student’s report of an experiment to measure the resistivity of nichrome wire.

“The resistance and length of the nichrome wire were found. The diameter of the wire was then measured at several points along its length.”

The following data was recorded.

Resistance of wire = 32.1 Ω

Length of wire = 90.1 cm

Diameter of wire = 0.19 mm, 0.21 mm, 0.20 mm, 0.21 mm, 0.20 mm

1. **Name an instrument to measure the diameter of the wire and describe how it is used.**

Digital callipers

Place the wire between the jaws

Tighten the jaws

Read the callipers

1. **Why was the diameter of the wire measured at several points along its length?**

To get an average because the material is not of uniform density.

1. **Using the data, calculate a value for the resistivity of nichrome.**

Average diameter = 0.202 mm

*A* = π*r*2 = 3.2 ×10−8 m2

ρ =RA/L

ρ = (32.1)(3.2 × 10-8)/0.901)

$ρ = \frac{RA}{l}$$ρ= \frac{\left(32.1\right)(3.2×10^{-8) }}{0.901}$ρ = 1.1×10−6 Ω m

1. **Give two precautions that should be taken when measuring the length of the wire.**

Ensure no kinks in wire, only measure length whose *R* value was measured, avoid parallax error, etc.

**2004 Question 5**

****

* 1. **Two forces are applied to a body, as shown.**

**What is the magnitude of the resultant force acting on the body?**

The resultant is the line joining the two tails to the opposite corner.

Mathematically, the length of the vector can be found by using Pythagoras’ Theorem

R2 = 52 +122

R = 13 N

We weren’t asked for the direction, but if we were it could be found as follows:

The direction is from the tails to the opposite corner (angles usually given relative to the horizontal).

The angle can be found by using Tan θ = $\frac{Opposite}{Adjacent}$
So θ = Tan-1 ($\frac{Opposite}{Adjacent}$) θ = tan-1 $\frac{5}{12}$ θ = 22.620



* 1. **A can of height 10 cm is submerged in water.**

**What is the difference in pressure between the top and bottom of the can?**

Solution

Change in pressure ΔP = (ρ)(g)(Δh) = (1000)(9.8)(0.1) = 980 Pa

* 1. **Explain the term thermometric property.**

A thermometric property is a property that changes measurably with temperature.

* 1. **The sound intensity doubles as a person approaches a loudspeaker. What is the increase in the sound intensity level?**

3 dB

* 1. **Two converging lenses, each with a focal length of 10 cm, are placed in contact. What is the power of the lens combination?**

*f* = 10 cm = 0.1 m $P\_{1=}\frac{1}{f}$ $P\_{1=}\frac{1}{0.1}$ P1 = 10 m-1 P2 = 10 m-1

PTotal = P1 + P2 = 20 m-1

* 1. **What is meant by polarisation of waves?**

A polarized wave is a wave which vibrates in one plane only.

* 1. **Identify two hazards caused by static electricity.**

Electric shock / explosion in flour mills /explosion when fuelling aircraft/ damage to electronic devices / electrical storm / static cling, etc.

* 1. **The activity of a radioactive isotope decays to 1/16th of its original value after 36 years.**

**What is the half-life of the isotope?**

1 → 1/2 → 1/4 → 1/8 → 1/16

It takes 4 half-lives to get from the original amount to 1/16th of the original.

4 half-lives took 36 years, so one half-life must be 9 years.

Answer: 9 years

* 1. **Give one use of the earth’s magnetic field.**

Navigation, protective layer around the earth which deflects dangerous cosmic rays.

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

Up, down, down.

**2004 Question 6**

1. **Define force.**

Force is something which can cause an acceleration.

1. **Define momentum.**

Momentum is the defined as the product of mass and velocity.

1. **State Newton’s second law of motion.**

Newton’s Second Law of Motion states that the rate of change of an object’s momentum is directly proportional to the force which caused it, and takes place in the direction of the force.

1. **Hence, establish the relationship: force = mass × acceleration.**

From Newton II: Force is proportional to the rate of change of momentum

F ∝ (mv – mu)/t F ∝ m(v-u)/t F ∝ ma F = k (ma) but k=1 F = ma

1. **Calculate the velocity of the bob just before the collision.**

Potential energy at the top = kinetic energy at the bottom

mgh = ½ mv2

v2 = 2gh = 2(9.8)(0.2)  v = 1.98 m s-1

1. **Calculate the velocity of the block immediately after the collision.**

*{Total momentum before collision = total momentum after collision*

*Only the pendulum bob has momentum before collision because it’s the only thing moving*

*Only the block has momentum after the collision because it’s the only thing moving.}*

 (0.01)(2) = (0.008)(v2)  v2= 2.48 m s-1

1. **What was the average horizontal force exerted on the block while travelling this distance?**

v2 = u2 + 2as  0 = (2.5)2 + 2a(2) a = 1.56 m s-2

F = ma = (0.008)(1.6) = 0.013 N

**2004 Question 7**

1. **Define specific heat capacity.**

The specific heat capacity of a substance is the heat energy needed to change one kilogram of the substance by one Kelvin.

1. **Define specific latent heat.**

The specific latent heat of a substance is the amount of heat energy need to change the state of 1 kg of the substance without a change in temperature.

1. **Calculate the energy required to convert the water into ice at a temperature of –20 oC.**

There are 3 separate stages here:

Cooling from 15 0C to 0 0C: Q = mcΔθ = (0.5)(4200)(15) = 31500 J

Change of state: Q = ml = (0.5)(3.3 × 105) =165000 J

Cooling ice from 0 oC to -20 oC: Q = mcΔθ =(0.5)(2100)(20) =21000 J

Total energy required = Qt = Q1 +Q2 +Q3 =217500 = 2.2 × 105 J

1. **How much energy is removed every second from the air in the freezer?**

*{Power rating = 100W = 100 Joules per second.*

*But 80% efficiency means that the useful power is actually 80 W}*

So 80 J of energy is removed every second.

1. **How long will it take the water to reach a temperature of –20 oC?**

$time required=\frac{energy which needs to be removed}{number of joules of energy removed per second}$ $t=\frac{217500}{80}$ = 2700 s

1. **Explain how this process cools the air in the freezer.**

 This change of state which takes place inside the pipe requires energy (latent heat). This energy is available from the air surrounding the pipe which is inside the freezer; this therefore lowers the temperature of the freezer.

1. **The freezer causes the room temperature to rise. Explain why.**

When the vapour condenses inside the pipe (at the back of the freezer) latent heat energy is released to the surroundings. This causes the air outside the pipe (the air in the room) to increase in temperature.

**2004 Question 8**

1. **Define potential difference.**

The potential difference (p.d.) between two points is the work done in bringing a charge of 1 Coulomb from one point to the other.

1. **Define capacitance.**

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

1. **Describe an experiment to demonstrate that a capacitor can store energy.**
2. Set up as shown.
3. Close the switch to charge the capacitor.
4. Remove the battery and connect the terminals together to ‘short’ the circuit.
5. The bulb will flash as the capacitor discharges, showing that it stores energy.

****

1. **Calculate the potential difference across the resistor and hence the potential difference across the capacitor.**

V (across 47 kΩ resistor) = (80 ×10−6 )(47 ×103 ) = 3.76 V

*{Total potential difference (provided by the battery) = potential difference across the resistor plus potential difference across the capacitor}*

V (across the capacitor) = 6 − 3.76 = 2.24 V

1. **Calculate the charge on the capacitor at this instant.**

$C=\frac{Q}{V}$ * Q* = *CV*  *Q* = (50 ×10−6 )(2.24) *Q* = 1.12 × 10-4 C

1. **Calculate the energy stored in the capacitor when it is fully charged.**

E = ½ CV2  E = ½ (50 ×10− 6)(6 )2 E = 9 ×10−4 J

1. **Describe what happens in the circuit when the 6 V d.c. supply is replaced with a 6 V a.c. supply.**

The current will flow continually.

**2004 Question 9**

1. **Distinguish between photoelectric emission and thermionic emission.**

The photoelectric effect is the emission of electrons when light of suitable frequency falls on a metal.

Thermionic emission is the emission of electrons from the surface of a hot metal.

1. **Explain why the leaves of the electroscope collapse.**

Photoelectric emission occurs (electrons get emitted from the surface of the metal).

The leaves lose their excess charge and therefore collapse.

1. **Explain why the leaves do not collapse when the zinc is covered by a piece of ordinary glass.**

Ordinary glass absorbs UV light (does not allow UV light to pass through)

1. **Explain why the leaves do not collapse when the zinc is illuminated with green light.**

The energy associated with photons of green light is too low for the photoelectric effect to occur, so no electrons are emitted from the electroscope.

1. **Explain why the leaves do not collapse when the electroscope is charged positively.**

Any electrons emitted are attracted back to the positive electroscope.

1. **Calculate the threshold frequency of zinc.**

*{First we need to convert the energy from eV to Joules, using 1eV = 1.6 × 10–19 Joules}*

The symbol for work function is φ, so φ = 4.3 eV = (4.3)( 1.6 × 10–19) Joules = 6.88 × 10–19 Joules

*Next we use* ***E = hf0*** *to calculate the threshold frequency*

E = φ = hf0  $f\_{0}=\frac{E}{h}$ $f\_{0}=\frac{E}{h}$ $f\_{0}=\frac{6.88 × 10^{-19}}{6.6 × 10^{-34}}$ *f0* = 1.04 × 1015 Hz

1. **Calulate the maximum kinetic energy of an emitted electron.**

Energy of incident photon = Energy required to free an electron + kinetic energy of photo-electron.

**hf = φ + Ek**

*{We don’t know the frequency of the incident ultraviolet light, but we can know that the wavelength is 240 nm, so we can work out the frequency using c = fλ or* $f=\frac{c}{λ}$ *}*

$f=\frac{3.0 ×10^{8}}{240 ×10^{-9}}$ = 1.25 × 1015 Hz

hf = φ + Ek Ek = hf - φ

Ek = hf - φ

Ek = [(6.6 × 10–34)( 1.25 × 1015)] - (1.04 × 1015)

Ek = 1.39 × 10-19 Joules

**2004 Question 10 (a)**

1. **List two other fundamental forces of nature and give one property of each force.**

Strong nuclear force: acts on nucleus/protons + neutrons/hadrons/baryons/mesons, short range

Gravitational force: attractive force, inverse square law/infinite range, all particles

Electromagnetic force: acts on charged particles, inverse square law/infinite range

1. **Write a nuclear equation for this decay.**

$$+$$

1. **Calculate the energy released during the decay of a neutron.**

Mass before = mass of neutron = 1.6749 × 10–27 kg

Mass after = mass of proton + mass of electron

 = 1.6726 × 10–27 + 9.1094 × 10–31 = 1.6817 × 10–27 kg

Loss in mass (mass defect) = (1.6749 × 10–27 kg) – (1.6817 × 10–27 kg)

 = 1.3891 × 10-30 kg

E = mc2 = (1.3891 × 10-30)(2.9979 × 108)2 = 1.25 × 1013 J

1. **Explain how the existence of the neutrino, which was first named by Enrico Fermi, resolved this.**

Momentum and energy are conserved when the momentum and energy of the associated neutrino are taken into account.

1. **What is nuclear fission?**

Fission is the splitting of a large nucleus into two smaller nuclei with the release of energy.

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

It slows down the fast neutrons (so that they in turn can be captured by the uranium atoms and cause the uranium nuclei to undergo fission).

1. **How did the cadmium rods control the rate of fission?**

They absorbed the neutrons which would otherwise cause fission.

**2004 Question 11**

* 1. **Name and give the colour of the wire that should be connected to the fuse in a standard three-pin plug.**

Live

Brown / red

* 1. **Explain why replacing a fuse with a piece of aluminium foil is dangerous.**

If a very large current flows the foil may still not break and so may start a fire.

* 1. **A table lamp has a power rating of 100 W. What is the most suitable fuse for the lamp?**

*P=VI* $I=\frac{P}{V}$ $I=\frac{100}{230}$ I=0.43 Amps

  So the most suitable fuse would be a 0.5 Amp fuse

* 1. **Why is an earth wire not required in these devices?**

All external parts are electrical insulators (usually plastic) so even if part of the external part does go live the current won’t travel across the surface so there should be no danger of shock.



* 1. **Sketch a voltage-time graph of the 230 V supply.**

Labelled axes: time on the horizontal and voltage on the vertical.

* 1. **Explain how a Residual Current Device (RCD) operates.**

It detects current in the live and the neutral and trips (shuts off) if there is a difference between them.

* 1. **Give one advantage of a Residual Current Device (RCD) over a Miniature Circuit Breaker (MCB).**

RCD responds very quickly, RCD responds to tiny currents

* 1. **Storage heaters have a large heat capacity. Explain why.**

Storage heaters are designed to take the heat in at night-time when it is less expensive and release it the following day.

Having a large heat capacity means that the heater can take in a lot of energy without a big rise in temperature. This in turn means that it should only lose the heat back out to the environment relatively slowly. It therefore should still contain plenty of heat energy the following day when it is most needed.

**2004 Question 12 (a)**

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. **What provides this centripetal force?**

Gravitational pull of the sun.

1. **In what direction does this centripetal force act?**

Towards the centre.

1. **Give an expression for centripetal force.**

$F\_{c}=\frac{mv^{2}}{r}$

1. **Calculate the mass of the sun.**

 and **** v2 $M\_{s}=\frac{RV^{2}}{G}$

$M\_{s}=\frac{(1.5 ×10^{11})(3.0 ×10^{4})^{2}}{6.7 × 10^{-11}}$ Ms = 2.0 × 1030 kg.

**2004 Question 12 (b)**

1. **Give two reasons why the telecommunications industry uses optical fibres instead of copper conductors to transmit signals.**

Less interference, cheaper raw material, occupy less space, more information carried in the same space, flexible for inaccessible places, do not corrode, etc

****

1. **Explain how a signal is transmitted along an optical fibre.**

Inner core has a greater refractive index than the outer core.

A light ray is introduced at one end of the fibre and strikes the interface at an angle greater than the critical angle so total internal reflection occurs.

This continues all along the fibre.

1. **An optical fibre has an outer less dense layer of glass. What is the role of this layer of glass?**

Total internal reflection will only occur if the outer material has a greater refractive index.

It also prevents damage to the surface of the core.

1. **An optical fibre is manufactured using glass of refractive index of 1.5.**

**Calculate the speed of light travelling through the optical fibre.**

$refractive index=\frac{speed of light in air}{speed of light in medium}$

$c\_{glass}=\frac{C\_{medium}}{refractive index}$ $c\_{glass}=\frac{3 × 10^{8}}{1.5}$ Cglass = 2.0 × 108 (m s-1)

**2004 Question 12 (c)**

1. **What is electromagnetic induction?**

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

1. **Describe an experiment to demonstrate electromagnetic induction*.***

Set up as shown.

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

1. **A light aluminium ring is suspended from a long thread as shown in the diagram.**

**When a strong magnet is moved away from it, the ring follows the magnet. Explain why.**

An emf is induced in the ring due to the motion of the magnet. This in turn induces a current in the ring which has a magnetic field associated with it.

The direction of the induced magnetic field is such as to oppose the change which caused it. Therefore the side of the ring facing the north pole of the magnet becomes a *south* pole and the ring and magnet attract each other, so the ring follows the magnet.

1. **What would happen if the magnet were moved towards the ring?**

*An emf is induced in the ring due to the motion of the magnet. This in turn induces a current in the ring which has a magnetic field associated with it.*

*The direction of the induced magnetic field is such as to oppose the change which caused it. Therefore the side of the ring facing the north pole of the magnet becomes a* ***north*** *pole and the ring and the magnet repel each other.*

Answer:

The ring would be repelled.

**2004 Question 12 (d)**

1. **What is doping?**

Doping is the addition of a small amount of atoms of another element to a pure semiconductor to increase its conductivity.

1. **Explain how a depletion layer is formed at the junction.**

Electrons from n-type material and holes from p-type material both cross the common junction (caused by thermal agitation) and cancel out with charge carriers on the other side.

As a result a narrow insulating region is formed which now acts as a ‘barrier’ or depletion layer.

1. **Explain, using the graph, how the current varies with the potential difference.**

Very little current flows between 0 V and 0.6 V

If the potential difference is greater than 0.6 V the current starts to increase very quickly.

1. **Why does the p-n junction become a good conductor as the potential difference exceeds 0.6 Volts?**

The depletion layer is overcome and as a result a large current flows.