**2011 Leaving Cert Physics Solutions (Higher Level)**

**2011 Question 1**

A student carried out an experiment to verify the principle of conservation of momentum.

The student adjusted the apparatus till a body A was moving at a constant velocity *u*.

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

The following data were recorded:

mass of body A ........... = 230 g

mass of body B ........... = 160 g

velocity *u* .................... = 0.53 m s–1

velocity *v ....................* = 0.32 m s–1

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

Track/means of coalescing, two trolleys, labelled means of measuring time/velocity (e.g. motion sensor)

1. **What adjustments did the student make to the apparatus so that body A would move at constant velocity?**

Adjust gradient of track, lubricate trolley wheels, polish/brush track, clear holes (air track), etc.

1. **How did the student know that body A was moving at constant velocity?**

Dots on the ticker tape were equally spaced / same time interval shown by both light gates / horizontal line on *v* vs. *t* graph (datalogging method)

1. **Describe how the student measured the velocity *v* of the bodies after the collision.**

Time between dots = 0.02 secs

We measured the distance for 10 intervals so the time was 10 × 0.02 = 0.2 seconds.

Velocity = distance ÷ time

OR

Using a data-logger select an appropriate set of points on a distance v.s time graph

Use the slope tool to give the velocity

1. **Using the recorded data, show how the experiment verifies the principle of conservation of momentum.**  
   momentum = mass × velocity  
   initial momentum = (0.230)(0.53) = 0.1219 kg m s-1  
   final momentum = (0.390)(0.32) = 0.1248 kg m s-1

principle verified since 0.1219 is approximately equal to 0.1248

1. **How could the accuracy of the experiment be improved?**

Use digital balance / select more dots / select greater distance/displacement /avoid parallax error

**2011 Question 2**

During an experiment to verify Boyle’s law, the pressure of a fixed mass of gas was varied. A series of measurements of the pressure *p* and the corresponding volume *V* of the gas was recorded as shown. The temperature was kept constant.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *p*/kPa | 325 | 300 | 275 | 250 | 200 | 175 | 150 | 125 |
| *V*/cm3 | 12.1 | 13.0 | 14.2 | 15.5 | 19.6 | 22.4 | 26.0 | 31.1 |

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

See diagram (it must include a pressure gauge, scale for reading volume and means of adjusting *p* or *V*

1. **How was the pressure of the gas varied during the experiment?**

We rotated the wheel

1. **Describe how the pressure and the volume of the gas were measured.**  
   The pressure was measured using the pressure gauge; the volume was read from the scale on the container.
2. **Why should there be a delay between adjusting the pressure of the gas and recording its value?**To allow for the gas to cool (reach thermal equilibrium with the environment)
3. **Draw a suitable graph to show the relationship between the pressure and the volume of a fixed mass of gas.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1/V | 0.0826 | 0.0769 | 0.0704 | 0.0645 | 0.0510 | 0.0446 | 0.0385 | 0.0322 |



1. **Explain how your graph verifies Boyle’s law.**  
   We got a straight line through the origin, verifying that pressure is inversely proportional to volume.

**2011 Question 3**

In an experiment to measure the wavelength of a monochromatic light source, a narrow beam of light was incident normally on a diffraction grating having 400 lines per mm.

A number of bright images were observed.

The angles *θ* between the central bright image and the first two images to the left and right of it were measured and recorded in a table, as shown.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 2nd image to left of central image | 1st image to left of central image | 1st image to right of central image | 2nd image to right of central image |
| *θ*/*0* | 30.98 | 14.90 | 14.81 | 31.01 |



1. **Name a source of monochromatic light.**

Sodium lamp / laser

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

* Set up as shown.
* Measure the distance between the n = 0 and the n= 1 images.
* Measure the distance D
* Tan ϴ = x/D
* Repeat for all orders on both sides

1. **Using the data, calculate the wavelength of the monochromatic light.**

nλ = d Sin θ

d = 1/400,000

λavg = 642.3 nm

1. **What effect would each of the following changes have on the bright images formed:**
2. **using a monochromatic light source of longer wavelength**

Larger ϴ therefore the images would be more spaced out.

1. **using a diffraction grating having 200 lines per mm**

Smaller ϴ therefore the images would be closer together.

1. **Using a source of white light instead of monochromatic light?**

Each image would be a spectrum of white light.

**2011 Question 4**

A student investigated the variation of the current *I* through an electrolyte as the potential difference *V* across the electrolyte was changed. The electrolyte used was a solution of copper sulfate.

The electrodes used were made of copper.

The student recorded the following data:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *V*/V | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| *I*/mA | 0 | 30 | 64 | 93 | 122 | 160 | 195 |

1. **Draw a suitable circuit diagram for this investigation and label the components.**

power suppy unit, ammeter, voltmeter, electrolyte, electrodes

1. **How was the potential difference changed during the investigation?**

Adjust the dial / selector on the variable power supply unit (or adjust the rheostat).

1. **Draw a suitable graph to show the relationship between the current and the potential difference in this investigation.**

See graph

1. **Use your graph to calculate the resistance of the electrolyte.**

Slope = 0.0323

R = 1/slope = 30.96 Ω

1. **What was observed at the electrodes as current flowed through the electrolyte?**

The cathode got heavier / coated with fresh copper

The anode got lighter

**2011 Question 5**

* 1. **A car of mass 1500 kg is travelling at a constant velocity of 20 m s–1.  
     What force is required to stop it in a distance of 50 m?**

*We will need to use F = ma, but before we do that we first need to work out the acceleration.*

*v2 = u2 + 2as*

0 = (20)2 + 2(a)(50)

*a* = - 4 m s-2

*F = ma*

*F* = 1500a

*F* = - 6000 N

*The negative sign indicates that the force is in the opposite direction to that in which the car is moving.*

* 1. **Why does the value of *g*, the acceleration due to gravity, vary at different locations on the surface on the earth?**

Locations are at different distances from the earth’s centre / earth is not perfectly spherical / earth is not of uniform density etc.

* 1. **Why is a convex mirror used, instead of a plane mirror, as a door mirror on a car?**

A convex mirror offers a wider field of view

* 1. **What causes the Doppler effect?**

Relative motion between source (of waves) and observer

* 1. **The capacitance of a parallel plate air capacitor is 5 pF.**

**If the plates of the capacitor are 2 cm apart, what is the common area of the plates?**

A = 0.0113 m2

* 1. **A residual current device (RCD) as shown is rated 30 mA.**

**Explain the significance of this rating.**

RCD trips if more than 30 mA flows to earth (if the current difference between *L* and *N* is greater than 30 mA)

* 1. **The physicist Robert Millikan is usually associated with what physical quantity?**

The charge on an electron

* 1. **What property of light controls the current in a photocell?**

Intensity

* 1. **What is the role of neutrons in a nuclear reactor?**

To cause (nuclear) fission / to initiate reaction

* 1. **Give the difference between the quark composition of a baryon and of a meson.**

Baryon: 3 quarks or 3 anti-quarks

Meson: quark *and* antiquark

**or**

**Give two ways of reducing energy loss in a transformer.**

Laminate the core, wire of lower resistance, reduce hysteresis, reduce magnetic flux leakage, etc.

1. **Question 6**
   1. **Define the moment of a force.**

Moment of a force = force × perpendicular distance between the force and the fulcrum

**When the toy is knocked over, it always returns to the upright position. Explain why this happens.**

When the toy is in a non-vertical position its weight (acting through the centre of gravity which is in the middle of the toy) has a turning effect about the point of contact/fulcrum (which might be the bottom corner of the toy).

However when the toy is in *upright* position the weight continues to act through the centre but now there is no turning effect because the line of action of the force (weight) and the fulcrum (centre of the base) are now in the same place, so perpendicular distance is zero so the toy remains where it is.

*Good luck explaining all that in an exam.*

* 1. **State the conditions necessary for the equilibrium of a body under a set of co-planar forces.**

Vector sum of the forces = zero

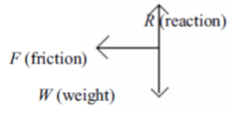
Sum of the clockwise moments about any point = sum of the anti-clockwise moments about that point

**Where should the third child of mass 45 kg sit, in order to balance the see-saw?**

30*g*(1.8) = 40*g*(0.8) + 45*g*(*x*)

*x* = 0.49 m

1. **Draw a diagram showing the forces acting on the child as the merry-go-round rotates.**

See diagram

**What is the maximum angular velocity of the merry-go-round so that the child will not fall from it, as it rotates?**

F = mω2r

*50 = 30 ω2(2.2)*

ω *= 0.842 rad s-1*

**If there was no force of friction between the child and the merry-go-round, in what direction would the child move as the merry-go-round starts to rotate?**

The child would remain stationary

*{The question wasn’t phrased very well as it suggests that the child was going to move}*

**Question 7**

**(a)**

1. **If the final temperature of the drink is to be 70 °C, what mass of steam should be added?**

energy gained by the milk = energy lost by the steam when condensing + energy lost by this condensed water cooling down

(*mc*Δθ)m  = (*ml*)steam  + (*mc*Δθ)condensed steam

(0.160)(3.90×103)(50) = (*m*steam)(2.34×106) + (*m*steam)(4.18×103)(30)

= 12.655×10-3 kg = 12.66 g

1. **What is the heat capacity of the spoon?**

The hot drink now consists of 160 grams of hot milk plus 12.66 grams of steam.

Total mass = 17.266 grams = 0.17266 kg

{It looks like we are missing a value for the mass of the spoon, but we are being asked to calculate the *heat capacity* (*C*), not the *specific heat capacity* (*c*). The relationship between C and c is: *C = mc*

Energy gained by the spoon = energy lost be the hot drink

(*C*Δθ)spoon = (*mc*Δθ)hot drink

48C = (0.17266)(4.05×103)(2)

48C = 1.3985×103

C = 29.14 J K-1

**(b)**

1. **Name two processes by which a hot drink cools.**

**How is the energy lost by each of these processes reduced for a hot drink supplied in a disposable cup?**

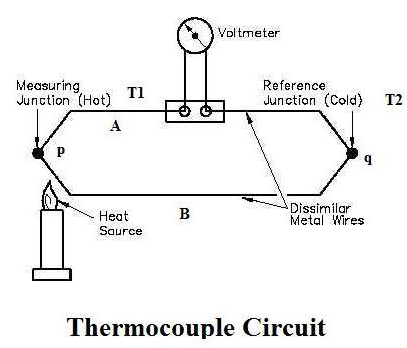
Conduction – The material the cup is made from is a good insulator

Evaporation – use a lid

Convection – Use a lid /insulation

**(c)**

1. **How would you demonstrate the principle of operation of a thermocouple?**

* A thermocouple is comprised of two different metals joined together at both ends to form two junctions (see diagram).
* One junction is connected to a body of known temperature: this is the *cold* or *reference* *junction*.
* The other junction is connected to the body whose temperature is to be measured: this is the *measuring junction*.
* Observation: e.g. emf /voltage is observed (as seen in the diagram).
* Increase the temperature of the heat source and note that the voltage increases also.

1. D**escribe how to establish a calibration curve for a thermocouple.**

* Hold one junction at constant temperature (eg oC)
* Hold the other junction in water beside an (already calibrated) thermometer.
* Heat the water (in steps of 10 oC approx) and note temperature and emf values each time.
* Plot a graph of emf vs. temperature.

**2011 Question 8 (a)**

1. **Explain the underlined terms**

Coherent waves are waves which are the same frequency (or wavelength) and are in phase

1. **Give two other conditions necessary for total destructive interference to occur.**

The waves must have the same amplitude and be out of phase by 1800 (crests over troughs).

1. **Name the points on the wave labelled P and Q.**

P represents a node, Q represents an anti-node.

1. **Calculate the frequency of the standing wave.**

The shape corresponds to 5/4 wavelengths λ = 0.720 m

*v = fλ*

*f* = 472.2 Hz

1. **What is the fundamental frequency of the pipe?**

The shape for the fundamental frequency corresponds to ¼ of a wavelength

= 0.90 λ = 3.60 m f0 = 94.44 Hz



1. **What type of harmonics is produced by a clarinet?**

Odd harmonics

Why odd?

See diagram. The length will either by etc

So it’s always an *odd* multiple.

Hence the term odd harmonics.

**2011 Question 8 (b)**

1. **Calculate the sound intensity experienced by a listener at a distance of 8 m from the speaker.***The sound from the speaker expands in all directions, like an inflating balloon. The area that the energy is passing through therefore corresponds to the surface area of a sphere (A = 4πr2)*

SI = 0.124 W m-2

1. **The listener moves back from the speaker to protect her hearing. At what distance from the speaker is the sound intensity level reduced by 3 dB? (speed of sound in air = 340 m s–1)**

If the *sound intensity level* decreased by 3dB it means sound intensity went down by a factor of two (it went from 0.124 W m-2 to 0.062 W m-2).

R = 11.33 m

**2011 Question 9 (a)**

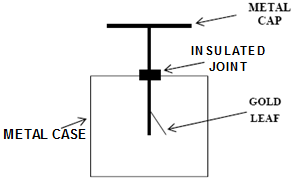
1. **State Coulomb’s law.**

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. **What is the new force, in terms of *F*, between the spherical conductors?**

**=**

**2011 Question 9 (b)**

1. **Draw a labelled diagram of an electroscope.**

See diagram

1. **Why should the frame of an electroscope be earthed?**

If the frame was charged it would affect the degree of deflection of the leaf.

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

**2011 Question 9 (c)**

1. **How does a full-body metal-foil suit protect an operator when working on high voltage power lines?**

Even if the operator touches a live wire all charges will reside on the *outside* of the conducting suit so he won’t get shocked.

1. **Describe an experiment to investigate the principle by which the operator is protected.**
2. Charge a hollow conductor (a metal can will do fine).
3. Using a proof plane, touch the inside of the can and bring it up to the GLE.

Notice that there is no deflection.

1. Touch the proof plane off the outside of the can and bring it up to the GLE.

Notice that there is a deflection.

1. Conclusion: charge resides on outside only

**2011 Question 10** **(*a*)**

1. **List three quantities that are conserved in nuclear reactions.**

Momentum, charge, mass-energy

1. **Write an equation for a nucleus undergoing beta-decay.**
2. **In initial observations of beta-decay, not all three quantities appear to be conserved.**

**What was the solution to this contradiction?**

The discovery of the neutrino which accounted for the missing momentum.

1. **List the fundamental forces of nature in increasing order of their strength.**

gravitational < weak (nuclear) < electromagnetic < (strong) nuclear

1. **Which fundamental force of nature is involved in beta-decay?**

The weak force.

1. **Why are new particles produced in the collision?**

The kinetic energy of the protons is converted into mass.

1. **Write an equation to represent the collision.**

p + p p + p + + + π-

1. **Show that the kinetic energy of each incident proton must be at least 140 MeV for the collision to occur.**

We need to find out how much energy is required to produce two pions.

So we will be using E = 2mπc2 where mπ represents the mass of one pion.

But we don’t have a value for the mass of a pion, just it’s mass relative to the mass of an electron.

Mass of π+ = (273)(me) = 273(9.109×10-31 kg) = 2.4869×10-28 kg

E = 2mπc2

E = 2(2.4869×10-28)(3×108)2 = 44.76 ×10-12 J

We now need to convert this to eV. 1 eV = 1.602 ×10-19 Joules, so we need to divide the our number in Joules by 1.602 ×10-19 to get the equivalent value in eV.

This is the *total* kinetic energy associated with two protons, so the kinetic energy of each proton must be 140 MeV.

**2011 Question 12 (*a*)**

1. **State Hooke’s law.**

For a stretched string the restoring force is proportional to displacement

1. **Why does the body vibrate with simple harmonic motion?**

The acceleration is proportional to the displacement

1. **Calculate the frequency of vibration of the body**

The general expression for simple harmonic motion is *a* = – 2*s*.   
The equation in this question is ***a* = – 16 *s***

Therefore we can assume that ω2 = 16 therefore ω = 4

and f = = = = 0.64 Hz

*Note that we can ignore the negative sign in the equation a = – 2s. It is there to reflect that the acceleration and displacement are opposite in direction.*

1. **What is the magnitude of (i) the maximum force, (ii) the minimum force, which causes the body’s motion?**

*a* = 2*s*.

*F*max occurs when acceleration is a maximum which according to our equation occurs when displacement (s) is a maximum.

Maximum displacement = amplitude = 5 cm = 0.05 m

*a*max = (16)(0.05) = 0.80

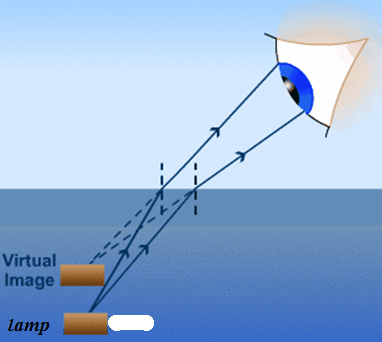
*F*max = (m)(amax) = (0.250)(0.80) = 0.20 N

The *minimum* force occurs when displacement is 0, so acceleration is 0, so Fmin = 0

**2011 Question 12 (b)**

1. **State the laws of refraction of light.**

The incident ray, refracted ray and normal all lie in same plane

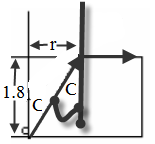
sin i/sin r is a constant

1. **Draw a ray diagram to show where the lamp appears to be, as seen by an observer standing at the edge of the pool.**

See diagram

1. **Explain why the area of water surrounding the disc of light appears dark.**

The angle of a ray of light coming from the lamp to a point on the surface *outside* the disc will be greater than the critical angle so gets totally internally reflected.

1. **Calculate the area of the illuminated disc of water.**

The formula for area of a disc is πr2, so we need a value for *r*.

First we can calculate a value for the critical angle *C* using

We were told in the question that the refractive index η = 1.33

ic = 48.760

From the wonderful diagram on the right, we can see that if we know C and the depth of the pool (which is 1.8 m), then we can use trigonometry to work out *r*.

*r* = 1.8 tan C *r* = 2.053 m Area = πr2 = π(2.053 )2

Area = 13.24 m2

**2011 Question 12 (c)**

1. **List the factors that affect the heat produced in a current-carrying conductor.**

Resistance, current (squared), time

1. **Calculate the maximum resistance per metre of the wire**

R = 6.75 × 10-3 Ω

1. **Calculate the minimum diameter of the wire (resistivity of copper = 1.7 × 10–8 Ω m).**

r = 9.0 × mdiameter = 1.8 ×10-3 m

**2011 Question 12 (d)**

1. **Name a suitable detector.**

GM tube (linked with a ratemeter/scaler)/ Solid state detector

1. **Describe how the reading on the detector may vary as the paper passes by.**

The count rate would decrease with increasing paper thickness.

1. **Why would the radioisotope Am-241, which emits alpha-particles, not be suitable for this process?**

The alpha-particles have poor penetrating power so would be easily blocked by the paper.

1. **Calculate the number of atoms present in a sample of Sr-90 when its activity is 4250 Bq.**

**The half-life of Sr-90 is 28.78 years.**

= (365)(24)(60)(60) = 31536000 seconds

T½ = = λ = λ = λ = 7.77 × 10-10 s-1

Activity = λN4250 = (7.77 × 10-10)(N) N = 5.47 × 1012 atoms