**2012 Leaving Cert Physics Solutions (Higher Level)**

**2012 Question 1**

In an experiment to measure the acceleration due to gravity using a simple pendulum, a student obtained values for the length *l* of the pendulum and the corresponding values for the periodic time T.

The student plotted the following point, based on the recorded data.

1. **Describe how the student obtained a value for the length of the pendulum and its corresponding periodic time.**

*Length*:

* Measure length (*l*) from fixed point to top of bob (using metre stick)
* Measure diameter/radius
* Length = *l* + *r* (stated or implied)
* Reference to metre rule and Vernier calipers (or micrometer)

*Periodic time:*

* measure time for *n* oscillations
* Divide (total time) by *n*
1. **Draw the appropriate graph on this examination paper and use it to calculate a value for *g*, the acceleration due to gravity.**



* Correct method for slope (–1 if (0,0) chosen as point on graph)
* Slope: 3.47 *m*  4.14
* *g* = 9.5 *g*  11.0 m s–2
1. **Give two factors that affect the accuracy of the measurement of the periodic time.**

Number of oscillations selected / the precision of the timer / repetition (of measurement for average) / smaller % error in *T* with longer lengths / nature of the string e.g. ‘inextensible string’

**2012 Question 2**

In an experiment to measure the focal length of a converging lens, a student measured the image distance *v* for each of four different values of the object distance *u*.

The table shows the data recorded by the student.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *u*/cm  | 12.0 | 18.0 | 23.6 | 30.0 |
| *v*/cm  | 64.5 | 22.1 | 17.9 | 15.4 |

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

Apparatus: e.g. ray box, convex lens, screen

Correct arrangement of apparatus

Adjust to get image in sharp focus

Measure *u* and *v*

Repeat for different positions of object

1. **Why is it difficult to measure the image distance accurately?**

Difficult to locate sharp image / centre of lens

1. **Using all of the data in the table, find the value for the focal length of the lens.**

Average *f* ( = 10.0 ± 0.2) cm

1. **Why is it difficult to measure the image distance when the object distance is less than 10 cm?**

Image is virtual / image on same side as object / no image formed on screen

**2012 Question 3**

In an experiment to investigate the variation of the fundamental frequency *f* of a stretched string with its length *l*, the following data were recorded.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| f/Hz | 95 | 102 | 114 | 126 | 141 | 165 | 194 | 232 |
| l/m | 0.603 | 0.553 | 0.503 | 0.453 | 0.403 | 0.353 | 0.303 | 0.253 |

1. **How were the data obtained?**
* Arrangement showing string, means of changing *l* , pulley and pan **/** newton balance / fixed at both ends

vibrating fork placed on bridge

* adjust length until standing wave formed / resonance occurs /rider falls
* measure length (between nodes / bridges)
* repeat with forks of different frequencies --- stated/implied
1. **Using the data, draw a suitable graph on graph paper to show the relationship between the fundamental frequency of the stretched string and its length.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| f/Hz | 95 | 102 | 114 | 126 | 141 | 165 | 194 | 232 |
| *l*/m | 0.603 | 0.553 | 0.503 | 0.453 | 0.403 | 0.353 | 0.303 | 0.253 |
| 1/*l* m-1 | 1.66 | 1.81 | 1.99 | 2.21 | 2.48 | 2.83 | 3.30 | 3.95 |



1. **The fundamental frequency of a stretched string depends on factors other than its length**

**Name one of these factors and give its relationship with the fundamental frequency.**

Tension in the string / mass per unit length of the string

f ∝ √T

f ∝ 1/√µ

1. **If you were doing an experiment to establish the relationship between the fundamental frequency of a stretched string and this other factor, how would you obtain the relevant data?**
* Find resonance for a fork *f* by changing tension
* Method for changing/measuring tension // keep *l* fixed
* Repeat for forks of different frequencies

**2012 Question 4**

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

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *V*/V  | 0 | 0.50 | 0.59 | 0.65 | 0.68 | 0.70 | 0.72 |
| *I*/mA  | 0 | 3.0 | 5.4 | 11.7 | 17.4 | 27.3 | 36.5 |

1. **Draw a circuit diagram used by the student.**
* apparatus: p.s.u., ammeter, voltmeter, diode
* correct arrangement
* diode in forward bias
1. **How did the student vary and measure the potential difference?**
* Vary using rheostat /variable resistor / dial on (variable) p.s.u.
* measure p.d. from voltmeter ( across diode – stated or implied)
1. **Using the data, draw a graph to show how the current varies with the potential difference for the semiconductor diode.**



1. **Does the resistance of the diode remain constant during the investigation?**

**Justify your answer.**

No

*I* is not proportional to *V* or equivalent, e.g. ‘graph is not a straight line through origin’.

1. **The student continued the experiment with the connections to the semiconductor diode reversed.**

**What adjustments should be made to the circuit to obtain valid readings?**

microammeter used (instead of ammeter/milliammeter) **//** voltmeter placed across diode and microammeter, etc.

**2012 Question 5**

* 1. **Cork and Sligo are about 330 km apart by road. Using the map of Ireland shown, estimate the displacement of Sligo from Cork. The scale of the map is 1 cm to 37.5 km.**

*This was a bizarre question in that the student had to use a ruler to measure the straight line distance between Sligo and Cork.*

This distance = 7.7 cm. Now we need to multiply this by 37.5

Displacement = (7.7)(37.5) = 288.75 km

*Note that displacement should also include a reference to direction;* Sligo is approximately due north of Cork.

* 1. **A pendulum moves with simple harmonic motion. Give another example of a body that moves with simple harmonic motion.**

A mass oscillating on a spring, a vibrating tuning fork

* 1. **The European aerospace group EADS is developing a hypersonic jet aircraft that will fly at four times the speed of sound, 330 m s-1. Express the speed of the aircraft in kilometres per hour.**

To convert from m/s to km/hr we need to do it in two stages; first convert *m* to *km* and then convert *seconds* to *hours*.

Before we do that we first need to calculate the actual speed of the aircraft: 4×330 = 1320 m s-1

Now to convert from *m* to *km* divide by 1000: 1320 m s-1 = 1.320 km s-1

To convert from *kilometres per second* to *kilometres per* *hour* multiply by (60)(60) or 3600:

1.320×3600 = 752 km h–1

* 1. **What is the focal length of a lens which has a power of -2 m-1?**

 = = – 0.50 m = –50 cm
*Strictly speaking we didn’t need to include the ‘minus’ sign; it merely signifies that it is a diverging or concave lens.*

* 1. **List three conditions necessary for an observer to see a rainbow.**

*A bit f#@kin’ stupid to look for three conditions. I could only get two ☹*
Observer’s back to sun / (bright) sunlight /(suspended) droplets of water /proper angle of viewing, etc.

* 1. **How is energy transferred from the sun to the earth?**

By means of electromagnetic radiation / photons

* 1. **A person smokes a cigarette at the entrance to a building. Explain how a significant amount of the smoke from the cigarette can enter the building.**

*See my comment to part (e). At this stage I’m beginning to think the person who set this paper was smoking something himself.*
(reference to) convection currents / diffusion / wind assisted / pressure variations, etc.



* 1. **Sketch the magnetic field due to a current in a solenoid.**

Uniform field inside solenoid / divergent field outside

* 1. **It takes 30 minutes for a 100 g sample of a radioactive isotope to decay to 12.5 g. What is the half-life of the radioisotope?**

It takes one half-life to go from 100 g to 50 g, another half-life to go from 50 g to 25 g and another half-life to go from 25 g to 12.5 g.

So 30 mins corresponds to 3 half-lives. Therefore one half-life = 10 mins = 60 seconds

* 1. **Which Irish physicist is associated with the development of the linear accelerator?**

Walton

**2012 Question 6**

1. **Calculate the acceleration due to gravity at a height of 31 km above the surface of the earth.**

d = distance to *centre* of the Earth = (6.36 × 106) + (31 × 103) =

*g* = 9.76 m s-2

1. **What was the downward force exerted on Kittinger and his equipment at 31 km, taking their total mass to be 180 kg?**

*F* = *W* = *mg*

*F* = 180(9.715) = 1748.7 N

1. **Estimate how far he fell during the first 13 seconds.**

**What assumptions did you take in this calculation?**

*s* = *ut* + ½ *at*2

*s* = ½ (9.715)(13)2

*s* = 820.92 m

*u* taken as zero / *g* is constant / no atmospheric resistance / no buoyancy due to atmosphere



1. **What was his average speed during the next 4 minutes and 36 seconds?**

Average speed =

Time = 276 seconds

Distance = 31000 – 820.92 –5000 = 25180 m

Average speed = = 91.23 m s–1

1. **How much was the force on a hemispherical parachute of diameter 8.5 m greater than that on a similar parachute of diameter 1.8 m?** so Force = (pressure)(area)

*We look at force in terms of pressure and area for both parachutes and compare them, bearing in mind that pressure remains constant.
The area in this case corresponds to the area of the parachute, which in turn corresponds to the surface area of a hemisphere; 2*

 = 22.3 times greater

1. **Calculate the upthrust that acted on Kittinger when he reached constant velocity in the last stage of his descent (assume *g* = 9.81 m s–2 during this stage).**

Upthrust is the upward-acting force, and if he was travelling at constant velocity then force up = force down.

Force down = weight = *mg* = (180)(9.81) = 1766 N

Upthrust = 1766 N

**2012 Question 7**

1. **Name the sections labelled A and B in the diagram.**

A: infra red /IR

B: ultra violet / UV

1. **Describe how to detect each of these radiations.**

A: thermometer (with blackened bulb) / temperature sensor /photographic plate / mobile phone camera

Effect e.g. rise in temperature *{Yup, I think this bit is daft also}*

B: (shine on) vaseline/detergents / phosphor

Effect e.g. fluorescence / glows *{refer to previous comment}*

1. **An electromagnetic radiation has a wavelength of 4 m.**

**Name the section of the electromagnetic spectrum in which this radiation is located.**

We can use the chart to help us here, but only if know the frequency
*c = f λ* = 7.5 × 107 Hz

We can see from the chart that this falls approximately half-way between the *short wave radio* and the *TV/FM radio* sections, so either answer would have been acceptable

1. **Distinguish between interference and diffraction.**

Interference occurs when waves from different sources overlap to form a resultant wave of greater or lower amplitude.

Diffraction occurs when a wave spreads around an obstacle or an aperture.

1. **Can a diffraction grating which diffracts light also diffract X-rays? Justify your answer.**

No.

For diffraction to occur the distance between slits (or line spacing) must be similar to the wavelength of the radiation, and the wavelength of light is very different to the wavelength of X-rays.

1. **Light travels as a transverse wave.**

**Name another type of wave motion and give two differences between these two types of wave motion.**

Longitudinal.

Transverse can be polarized – longitudinal cannot.

Transverse waves vibrate *perpendicular* to the direction in which the wave travels.

Longitudinal waves vibrate *parallel* to the direction in which the wave travels.

**2012 Question 8**

1. **Distinguish between nuclear fission and nuclear fusion.**

Fission: large nucleus splits into two smaller nuclei (of similar size)

Fusion: two small nuclei join to form a larger nucleus

1. **What are the advantages of fusion over fission in terms of fuel sources and reaction products?**

(hydrogen) fuel (from the sea) is plentiful – (uranium for fission is scarce)

no radioactive waste with fusion – (fission results in radioactive waste)

1. **How much energy is produced when a deuterium nucleus combines with a tritium nucleus?**

*See page 83 of log tables to get masses of the nuclei in terms of atomic mass units (u).
Then jump to page 47 to convert from atomic mass units to kg:* 1 *u* = 1.660 5402 × 10-27kg

*Pick your own adjective to describe this logic.*

2.014102 + 3.016049 → 4.002603 + 1.008672 + energy

5.030151 → 5.011275 + energy

Change in mass = 0.018875 u

1 *u* = 1.660 5402 × 10-27kg

0.018875 *u* = 3.1344 × 10-29 kg

E = mc2 = (3.1344 × 10-29)(3 × 108)2 = 2.82096 × 10-12 J

1. **Calculate the force of repulsion between a deuterium and a tritium nucleus when they are 2 nm apart in free space.**

*Note that the nuclei of deuterium and tritium both have just one proton (although deuterium has 1 neutron and tritium and 2 neutrons this doesn’t affect the charge).
The charge on a proton is the same as the charge on an electron: 1.602 ×10-19 C*

F = 5.77 × 10-11 N

1. **Fusion can only take place at very high temperatures. Explain why.**

Nuclei must have very high speeds / energy to overcome force of repulsion between the nuclei if they are to combine

**2012 Question 9**

1. **Define resistance.**

Resistance is the ratio of voltage to current / / *V* ÷ *I* plus correct notation

1. **Two resistors of resistance *R*1 and *R*2 are connected in series.**

**Derive an expression for the effective resistance of the two resistors in terms of *R*1 and *R*2**.



*VTotal* = *V*1 + *V*2

*(IR)Total* = *IR*1 + *IR*2

*R*Total = *R*1 + *R*2

1. **Two 4 Ω resistors are connected in parallel.**

**Draw a circuit diagram to show how another 4 Ω resistor could be arranged with these two resistors to give an effective resistance of 6 Ω.**



1. **A fuse is a resistor used as a safety device in a circuit. How does a fuse operate?**

The fuse in live part of circuit gets hot and melts/breaks if current exceeds a certain (rated) value.

This breaks the circuit.

1. A Wheatstone bridge circuit is used to measure the resistance of an unknown resistor R.

The bridge ABCD is balanced when X = 2.2 kΩ, Y = 1.0 kΩ and Z = 440 Ω.



**What test would you use to determine that the bridge is balanced?**

Connect galvanometer across points AC

No deflection in galvanometer when balanced

1. **What is the resistance of the unknown resistor R?**

R = 968 Ω

1. **When the unknown resistor R is covered by a piece of black paper, the bridge goes out of balance.**

**What type of resistor is it?**

Light dependent resistor / l.d.r. **/** photoresistor **/** CdS cell

1. **Give a use for this type of resistor.**

Used in light meters / (to control) street lights / security alarms / (control) traffic lights / used in re-charging circuits, etc.

**2012 Question 10** **(*a*)**

1. **What is a positron?**

A positron is an electron with a positive charge.

1. **When a positron and an electron meet two photons are produced.**

**Write an equation to represent this interaction.**

1. **Why are photons produced in this interaction?**

The mass of the electron and positron gets converted into energy

1. **Explain why two photons are produced.**

To conserve momemtum.

1. **Calculate the minimum frequency of the photons produced.**

*Two electron ‘disappear’ and two photons are created, so we can assume that the each electron ‘is converted to’ a photon.*

Mass of electron = 9.1093826 × 10-31 kg

The energy associated with an electron is given by *E = mc2*

*E* = (9.1093826 × 10-31)(3 × 108)2

*E* = 8.198444 × 10-14 J

This now becomes the energy of the photon:

*E = hf*

*f* = 1.237 × 1020 Hz

1. **Explain why the photons produced usually have a greater frequency than your calculated minimum frequency value.**

In addition to rest mass the colliding particles have kinetic energy.

1. **Why must two positrons travel at high speeds so as to collide with each other?**

To overcome the force of repulsion

1. **How are charged particles given high speeds?**

Particle accelerators / linear accelerator / cyclotron /synchrotron/magnetic fields/electric fields

1. **Explain why two positrons cannot annihilate each other in a collision.**

This would involve a conflict with conservation of charge.

**2012 Question 10 (b)**

**Draw a labelled diagram to show the basic structure of a bipolar transistor.**

**Indicate the difference in the composition of the parts of the transistor that you have drawn.**



Middle layer: base is thin and lightly doped / +holes are majority carriers

Outer layers: emitter and collector are thicker / *e*– are majority carriers

The diagram shows part of a circuit in which a transistor is to be used as a voltage inverter.

**Copy the diagram into your answerbook and complete the circuit diagram.**



1. Label each part of the circuit.
2. Indicate on your diagram the terminals used for the input and output voltages.
3. Draw a sketch of an input voltage and its corresponding output voltage, using the same axes and scale.
4. A voltage inverter can be used as a NOT gate.

Draw the symbol of a NOT gate.

1. Draw the truth table for a NOT gate.



1. **Give another application of a transistor.**

Switching, amplification, etc.

**2012 Question 11**

1. **What is the effect on the power of the wind if the wind speed is doubled?**

*P* = *ρAv*3 ⇒*P∝ v*3This means that if *v* doubles (increases by a factor of 2) then the power increases by a factor of 23 or 8 (gets 8 times bigger)

1. **Why is it not possible to extract all of the energy in the wind striking a wind turbine blade?**

The wind is slowed down rather than stopped

1. **What is electromagnetic induction?**
Electromagnetic induction occurs when an emf is induced in a coil due to a changing magnetic flux.
2. **How is the output voltage of a wind turbine changed to 230 V a.c.?**

Transformer

1. **Estimate the factor by which the sound intensity changes when you move from a position which is about 200 m away to a position which is about 150 m away from a typical wind turbine.**

Sound intensity level went from 42 dB to 45 dB, so increased by 3 dB

If the sound intensity level goes up by 3 dB then the sound intensity doubles *{this is just a general rule}*

1. **What is the tip speed (the linear velocity of the outer end) of a blade of radius 30 m when it completes a revolution every 3 seconds?**

 *{in one full revolution, the distance travelled by the tip corresponds to the circumference of a circle}*

*v* = 62.83 m s–1

1. **The a.c. output voltage has to be converted to a d.c. voltage. How is this achieved?**

By using a rectifier (made up of a 4 diodes).

1. **Name one other renewable source of energy.**

Geothermal, solar, etc.

**2012 Question 12 (a)**

1. **What is the angular velocity of the hammer during its final swing?**

 = 7.85 rad s-1

1. **Even though the hammer moves at a constant speed, it accelerates. Explain.**

Acceleration corresponds to a change in velocity, and velocity has both a magnitude *and* direction, so if *either* of these components changes then the velocity changes and the object accelerates.
So in this case thedirection changes continuously so the hammer is accelerating.

1. **Calculate the acceleration of the hammer during its final swing.**

a = ω2r

a = (7.85)2(2)

a = 123.37 m s-2 *towards the centre of orbit*

1. **Calculate the kinetic energy of the hammer as it is released.**

K.E. = ½ mv2

K.E. = ½ m(r ω) 2

K.E. = ½ (7.26)[(2)(7.85 )] 2

K.E. = 896 J

**2012 Question 12 (b)**

1. **If the refractive index of the glass is 1.5, calculate the value of *θ*.***This is one of the nastiest questions I have seen on any paper.**First, recognise that that θ does not represent the angle of incidence; you need to subtract the angle of incidence from 90 to get θ.**Secondly, the angle of refraction r is 600 not 300.**Finally, anytime you are told that the refractive index of a material is 1.5, what is implied is that light is going from air into this medium (go back and learn the full definition of refractive index to see why).
In this case the light is going from the medium (glass) to air, therefore the refractive index is*

 **=**

Therefore *i* = 35.260

Therefore *θ* = 54.740

Told you it was nasty

1. **What would be the value of the angle *θ* so that the ray of light emerges parallel to the side of the glass block?**

Here we don’t have to worry about the direction of light; the formula for the *critical angle* assumes that light is going from the medium to air.

c = 41.820

*θ* = 48.20

1. **Calculate the speed of light as it passes through the glass.**

 = 2 ×108 m s-1

**2012 Question 12 (c)**

1. **Explain the shape of the graph.**

Temperature of ice increased from –3o to 0o as energy is added.

Ice temperature stays at 0 0C while ice is melting / changing state - the heat taken in at this stage is known as *latent heat*.

Once all the ice has melted the water temperature increases to 1oC.

1. **Describe how energy could have been supplied at a constant rate.**

Using a heating coil (ideally with a joulemeter and rheostat to monitor and adjust the energy supplied).

1. **Using the graph, estimate the specific latent heat of fusion of ice.**

From the graph we can see that the energy required to melt 0.15 kg of ice = (59 kJ – 10 kJ) = 49 kJ

E = m*l*

*l* = 3.27 × 105 J Kg-1

**2012 Question 12 (d)**

1. **Draw a diagram to show the structure of a photocell.**
2. **Describe an experiment to demonstrate how the current through a photocell can be increased.**
3. Set us as shown in diagram.
4. Bring the light source closer to the photocell.
5. A greater deflection in the galvanometer (or ammeter) indicates that the current in the circuit has increased.
6. **Give an application of the photoelectric effect.**

Controlling the flame in central heating boilers / automatic doors / fire alarms / photocells / photocopiers / light meters, etc.