**2017 Leaving Cert Physics Solutions (Higher Level)**

**2017 Question 1**

1. **Why did the student use a small angle?**

Formula is valid only for a small angle / SHM occurs only for a small angle

1. **How did the student ensure that the pendulum was suspended from a fixed point?**split cork / two coins
2. **Between which points was the length of the pendulum measured?**
bottom of the cork/coins and the middle of the bob
3. **Which *t* value is most accurate?**
77.3 s
4. **Explain your answer.**
Smallest percentage error
5. **Draw a suitable graph to show the relationship between the length of a pendulum and its period.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *l* (m) | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| *T2* (s2) | 0.75 | 1.14 | 1.66 | 2.0 | 2.44 | 2.71 | 3.09 | 3.73 |

Divide *t* values by 40 and square them

Axes labelled

Points plotted

Straight line through origin

Good fit

1. **Use your graph to calculate *g*, the acceleration due to gravity.**
slope calculated using two points on line
substitute into formula

g ≈ 9.8 m s-2

**2017 Question 2**

1. **Draw a labelled diagram of the apparatus used.**
string, bridge(s), tuning fork/signal generator, paper rider, tension key/pan with weights
2. **Show on your diagram how the *tension* was measured.**
newton balance/pan with weights
3. **Show on your diagram how the *length* was measured.**
indication of where length is measured
4. **How was the fundamental frequency determined?**
change tuning fork / adjust signal generator / adjust tension until resonance observed
5. **How would a student use the measurements taken in this experiment to draw a graph showing the relationship between frequency and tension?**He would draw a graph of *f* against
6. **Explain how the graph verifies this relationship.**
A straight line through the origin would verify this
7. **Write an expression for μ in terms of *l* and *m*.**


*Compare this to the general equation for a line (through the origin): y = mx*

**2017 Question 3**

In an experiment to determine the specific latent heat of fusion of ice, warm water and ice were mixed in a copper calorimeter. The following data were recorded.

Mass of calorimeter = 61.8 g

Mass of calorimeter + warm water = 110.2 g

Initial temperature of calorimeter + warm water = 26.5 °C

Initial temperature of ice = 0.0 °C

Mass of added ice = 8.2 g

Final temperature of calorimeter + water + melted ice = 12.0 °C

(*specific heat capacity of copper = 390 J kg–1 K–1; specific heat capacity of water = 4180 J kg–1 K–1*)

1. **Describe how the mass of added ice was measured**
[mass of calorimeter + water + melted ice] – [mass of calorimeter + water**]**
2. **Describe how it was ensured that the temperature of all the added ice was at 0.0 °C.**
The ice was crushed and melting
3. **State two ways in which the calorimeter could have been insulated during this experiment.**
It could have been wrapped in cotton wool and a lid could have been used.
4. **Calculate the specific latent heat of fusion of ice.**

*mw = 48.4 g,*

Δθw = 14.5,
Δθi = 12.0

(*ml*)ice + (*mc*Δθ )melted ice = (*mc*Δθ ) water + (*mc*Δθ )cal
(8.2)*l* + (8.2)(4180)(12) = (48.4)(4180)(14.5) + (61.8)(390)(14.5)
*l* = 3.5 × 105 J kg–1

1. **State two characteristics of a thermometer suitable for use in this experiment.**
small heat capacity, graduated to 0.1 °C, suitable range, reacts quickly

**2017 Question 4**

1. **Draw a suitable graph to illustrate the relationship between current and potential difference*.***labelled axes

points plotted

good fit

1. **Use your graph to calculate the resistance of the filament (*i*) at 0.5 V and (*ii*) at 8.5 V.**
I = 5.5 mA at 0.5 V

*I* = 70 mA at 8.5 V

1. **As the potential difference was increased, at what point did the resistance of the filament begin to change significantly?**
4.0 V to 6.0 V
2. **Why does the resistance of a filament change with its potential difference?**As potential difference increases current increases

As current increases temperature increases

As temperature increases resistance increases

**2017 Question 5**

Answer any **eight** of the following parts, (*a*), (*b*), (*c*), etc.

1. **State Boyle’s law.**
For a fixed mass of gas at constant temperature pressure is inversely proportional to volume
2. **Calculate the new velocity of sphere B.**

m1u1 + m2u2 = m1v1 + m2v2

(0.4)(6) + (0.15)(-9) = (0.15)(v)

*v* = 7 m s-1

1. **What is the thermometric property (*i*) of a thermocouple and (*ii*) of a mercury thermometer?**

*i*) emf (*ii*) length/volume

1. **The diffraction effects of sound waves are noticeable in everyday life, whereas the diffraction effects of light waves are not. Explain why.**
Sound has a long wavelength / light has a short wavelength
2. **Explain how point discharge occurs.**
Charge accumulates at a point

Air is ionised around the point / like charges are repelled / unlike charges are attracted

1. **What is the electric field strength 53 pm from a proton?**
E =
E = Q/4πεd2

E = (1.6 × 10-19)/4π(8.9 × 10-12)(53)2
N C-1

1. **What is meant by sound intensity?**Sound intensity = power per unit area
2. **A certain RCD has a rating of 30 mA. What is the significance of this number?**
Current is cut off if the difference between live and neutral currents is greater than 30 mA
3. **What is the function of the moderator in a fission reactor?**
slows down neutrons / increase fission
4. **Explain why the gravitational force can be ignored for sub-atomic particles.**
masses are very small / force is proportional to mass /gravitational force is the weakest

*Or*

**How can a galvanometer be converted into a voltmeter?**
Large resistance in series

**2017 Question 6**

1. **State the principle of conservation of energy.**
Energy cannot be created or destroyed but only converted from one form to another
2. **Derive the expression *v2=u2+2as* for uniform accelerated motion.**

*v = u + at* ⇒ {multiply out both sides} (*v*)2 *=* (*u + at*)2 ⇒ v2 = u2 + 2uat + (at)2

*v2 = u2 + 2a(ut + ½ at2)*

*v2 = u2 + 2as* {because *s =ut + ½ at2***}**

1. **Calculate his speed when he has fallen 16 m.**

*v2 = u2 + 2as* *v2* = 0 + 2(9.8)(16) *v* = 17.7 m s-1

1. **State Hooke’s law**
Hooke’s law states that when a force is exerted to extend or compress a spring, the *restoring force* is proportional to the displacement.
2. **What is meant by simple harmonic motion?**
An object is said to be moving with Simple Harmonic Motion if its acceleration is directly proportional to its displacement *from* a fixed point in its path, and its acceleration is directed *towards* that point.
3. **Calculate the length the cord would have if Henry was suspended at rest.**
If Henry is at rest then the force upwards must equal the force downwards.

The force upwards is the tension in the string, which we know from Hooke’s is proportional to the extension (*d*), so *F*upwards = k*d*, where k is the proportional constant. In this case k corresponds to the elastic constant of the cord (250 N m-1).
*F*upwards = (250)*d*

The force downwards is simply his weight: *mg* = (9.8)(60)

(250)*d* = (9.8)(60)

*d* = 2.352 m = extension.
So the overall length of the cord = 32 + 2.35 = 34.35 m

1. Calculate (*i*) his maximum acceleration as he oscillates and (*ii*) his period of oscillation.

*Maximum acceleration:* From the equation *a* = - *ω*2 *x* the acceleration will be a maximum when the displacement (*x*) is a maximum. The question tells us that this maximum displacement is 1.2 metres.

Note that for simple harmonic motion we can use the relationship

 = 250/60 = 4.17 *a* = - *ω*2 *x* *a* = - (4.17)(1.2)

*a* = -5 m s-2

*His period of oscillation:*

1. **Draw a diagram to show the forces acting on Henry when he is at his lowest point.**
Arrow showing force down

Arrow showing force up

It must be clearly indicated that the force upwards is greater than the force downwards

**2017 Question 7**

1. **What is reflection?**
rebounding (of light) from an object
2. **What primary colours of light (*i*) are absorbed and (*ii*) are reflected when white light shines on a red book?**
White light is made up of red, green and blue light

When white light shines on a red book, it means that the green and blue must be absorbed while the red is reflected back to us.

1. **What colour would the red book appear to be if colour filters were used so that the book was illuminated (*iii*) with green light and (*iv*) with red light?**
We know that a red book absorbs green light so if you illuminate it with only green light then nothing will be reflected back so the book will appear black.

If you illuminate it with red light then we know that this will get reflected back so the book will appear red.

1. **What is polarisation?**
Wave vibrations in one plane only
2. **Describe how polarisation can be demonstrated in the laboratory.**

Two parallel polarising plates and a source of light

Rotate one plate until no light passes through the plates



1. **Give an application of stress polarisation.**

Checking for defects in plastics

1. **Describe, with the aid of a labelled diagram, how the Doppler effect occurs.**

Consider the soundwaves emitted from a car’s engine with crests as shown as it moves to the right:

*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 (more crests per second passing over the observer).

1. **The apparent frequency is 15% more than the actual frequency.**

 = 115% of *f* = 1.15 *f*

****  cancel the *f*s

(1.15)(340 – *u*) = 340 (1.15)(340) - (1.15)( *u*) = 340 (1.15)(340) + 340 = (1.15)( *u*)

u = 44.3 m s-1

**2017 Question 8**

1. **Distinguish between resistance and resistivity.**
The resistance of a conductor is the ratio of the potential difference across it to the current flowing through it.
Resistivity is defined as the resistance of a cube of material of side one metre.
2. **What is the effect on the resistance of a length of wire if the diameter of the wire is increased by a factor of three?**

The cross-sectional area A of a wire = πr2 = π

So area is proportional to the square of the diameter.

So if the diameter goes up by a factor of 3, the area will go up by a factor of 9.

Now what’s the relationship between resistance and area?

 

So R is inversely proportional to A.

So if the area goes up by a factor of the 9 the resistance will go down by a factor of 9 (get 9 times smaller)

Answer: The resistance decreases by a factor of 9

1. **What is meant by rms?**
Average (or ‘root mean square’) voltage
2. **What is meant by a.c.?**The current changes direction (alternating current).
3. **Calculate the effective resistance of the circuit** RP= 143 Ω RTotal= 143 + 50 = 193 Ω
4. **Calculate the current flowing in the 200 Ω resistor.**

 = = 0.062 A

Look for the isolated resistor

50 Ω resistor:

 I = 0.062 A, R = 50 Ω. V = IR = (0.062)(50) = 3.1 Volts

Look at remaining resistors

The voltage across the two resistors in parallel = 12 – 3.1 = 8.9 V, so the potential difference across both the 15 Ω and the 30 Ω resistors is 8.9 Volts.

 To find I use I = V/R

 Current through 200 Ω resistor = 8.9/200= 0.045 Amps

1. **What effect will this have on the current flowing in the 50 Ω resistor?**The overall current will reduce
2. **Explain your answer.**
Resistance of circuit is now greater
You could work this out mathematically if you were so inclined. Alternatively you could look at it from the perspective that there is one less path for the current to flow through.
3. **In each of the investigations, what effect did the replacement have on the current flowing?
Justify your answer in each case.**
When the resistor was replaced with a coil an emf was induced in the coil which opposed the driving emf so the overall voltage and current were reduced.

When the resistor was replaced with a diode the result was that the current could only flow in one direction – because that’s what a diode does.

**2017 Question 9**

1. **Describe Rutherford’s experiment to investigate the structure of the atom.**
He fired alpha particles at a very thin sheet of gold foil.

The alpha particles could be detected by small flashes of light that they produced on a fluorescent screen (see diagram).

He found that:

* Most alpha particles were undeflected and passed straight through the gold foil.
* Some were deflected through small angles.
* A very small number were turned back through angles greater than 900.
1. **What conclusions about the nature of the atom did Rutherford make?**
That it’s mostly empty space with a small/dense/positive core
2. **Explain, using the Bohr model, how line spectra are formed.**
Energy supplied in the form of heat or light.

Electrons move to a higher/excited energy level

Electrons fall down via specific levels emitting light of specific frequencies/wavelengths.

1. **Draw a labelled diagram of a spectrometer and describe how a spectrometer and diffraction grating can be used to observe (*i*) a line spectrum and (*ii*) a continuous spectrum.**
collimator (labelled)
table
telescope (labelled)
correct arrangement

**Line spectrum:** light source is a vapour lamp
**Continuous spectrum**: light source is a filament bulb / white light

1. **Calculate the angular separation between the first line to the left of the central image and the first line to the right of the central image.**

If the grating has 300 lines per mm then it must have 300000 lines per m (because 1 m = 1000 mm)

d=1/300000 = 3.33 ×10-6 m

*λ =* 589 × 10-9 m

*n =* 1

*nλ = d sin θ* θ = 10.20 Angular separation = 20.40

**2017 Question 10**

1. **What are X-rays?**
photons / electromagnetic radiation with high energy / short wavelength / high frequency
2. **How are the electrons produced?**
thermionic emission
3. **Where in the tube does this take place?**
cathode/filament
4. **Calculate the energy of an X-ray photon of wavelength 0.02 nm**
*E*= *hf c = fλ E*= *h E*= [6.6 × 10-34][]

*E* = 9.9 × 10-15 J
5. **Calculate the maximum velocity of an electron in the tube**
*E* = ½m*v*2
9.9 × 10-15 = ½ (9.1× 10-31)(*v*)2

*v* = 1.48 × 108 m s-1

1. **Calculate the voltage applied to the electrons.***W* = *VQ* *V* = 62000V
2. **Draw a labelled diagram of a photocell.**Anode

Semi-cylindrical cathode

Case and vacuum

1. **Describe how a photocell conducts current.**Light (of suitable frequency) falls on cathode.

Electrons are emitted

1. **How many electrons are generated in the photocell during each minute?**

*Q* = *It* = (2 × 10-6)(60) = 1.2 × 10-4 coulombs

1 electron = 1.6 × 10-19 coulombs

Number of electrons = = 7.5 × 1014 electrons

**2017 Question 11**

1. **Draw a labelled diagram of an arrangement of apparatus that could be used to demonstrate the principle that a current-carrying conductor experiences a force in a magnetic field.**

**Demonstration**

1. Set up as shown.
2. Turn on the power supply.
3. The foil moves up (or down - depending on the direction of the current).
4. **Explain how this principle is used in the definition of the ampere.**
current flows in two (parallel) conductors

1 metre apart (in a vacuum)

Force of 2 × 10–7 N per metre
*{I would take issue with the marking scheme here – it was not remotely clear that the answer above is what was required.
If they wanted a definition then they should have asked for a definition}*

1. **Draw a circuit diagram of a Wheatstone bridge.**
Four resistors in correct arrangement – see diagram

Galvanometer/ammeter/voltmeter in correct position

1. **Why did *Telstar* not allow transatlantic signals to be transmitted constantly?**
Because the period of Telstar is different to the period of Earth / not in geostationary orbit / not always above the same place
2. **Calculate the radius of orbit of *Telstar*.**
****

*r* = 9.6 ×106 m

1. **With the aid of a labelled diagram, explain how light is transmitted through optical fibres.**
2. An optical fibre consists of a glass pipe coated with a second material *of lower refractive index*.
3. Light enters one end of the fibre and strikes the boundary between the two materials *at an angle greater than the critical angle,* resulting in total internal reflection at the interface.
4. This reflected light now strikes the interface on the opposite wall and gets totally reflected again.
5. **Calculate the refractive index of the glass used in the cable.**

Speed of light in air = 3 × 108 m s-1

Speed of light in glass = = 1.9 × 108 m s-1

 = 1.58

1. **What particles are used for transatlantic communication (*i*) in telegraph cables,(*ii*) in satellite signals and (*iii*) in optical fibres?**
telegraph cables - electrons

satellite signals - photons

optical fibres – photons

**2017 Question 12 (a)**

1. **State the laws of equilibrium.**

1. The vector sum of the forces in any direction is zero

2. The sum of the moments about any point is zero

1. **Calculate the clockwise moment acting on the rod (due to the weight of the sign and the weight of the rod) about X.**

There are 2 forces here; the weight of the sign and the weigh of the rod (acting through the centre of gravity of the rod)

Moment of force = (400)(1.2) + (330)(0.6) = 678 N m

1. **Hence calculate the tension in the cable.**

Total clockwise moment = anti-clockwise moment

Anti-clockwise moment = force (T) × perpendicular distance

The *perpendicular distance* refers to the perpendicular distance between the fulcrum (at X) and the line that the force *T* is acting in (referred to as ‘the line of the force’). This is indicated by the distance *d* in the diagram.

From trigonometry we can see that the distance

Anti-clockwise moment = (T) × perpendicular distance

Total clockwise moment = anti-clockwise moment

 T = 985 N

1. **A rotating object can be in equilibrium. Explain how this can happen.**
If can be in equilibrium if its angular velocity is constant

**2017 Question 12 (b)**

1. **What is meant by radioactivity?**
Radioactivity is the (spontaneous) disintegration of unstable *nuclei* with the emission of one or more types of radiation.
2. **Name a device used to detect beta-radiation and explain its principle of operation.**
Geiger-Muller tube
ionisation
3. **Write the nuclear equation for this decay.**
4. **Calculate the number of potassium–40 nuclei in this person.**
The symbol for the number of nuclei is *N* and the formula that relates *N* to the activity is: *A =* λ *N*

So first we need to find λ - the decay constant.

Remember that we were told that potassium–40 has a half-life of 1.25 × 109 years.
We will need to convert this into seconds.

*A =* λ *N*

N = 2.07 × 1020 nuclei

**2017 Question 12 (c)**

1. **Draw a ray diagram to illustrate how Rembrandt used a concave mirror in this way.**



1. **Calculate the distance from the sheet to the mirror.**

 *u* = 2*v*

 *v* = 90 cm

1. **Calculate the distance from the object to the mirror.**

*u* = 2*v u* = 180 cm

1. **Explain why this image was not of use to Rembrandt.**
The image formed would be a virtual image which could not be formed on a sheet

**2017 Question 12 (d)**

Answer either part (i) or part (ii).

1. **Explain how the protons were produced.**ionisation / discharge tube
2. **Explain how the protons were accelerated.**
high voltage
3. **Explain how the alpha-particles were detected.**

flashes / zinc sulphide / screen

1. **Write the nuclear equation for this reaction.**
** +  →  + K.E.**

For this reaction, calculate the loss in mass and hence the energy released (in MeV).
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) = 2.7 × 10-12 J

Converting to eV: 1.6 × 10-19 J = 1 eV

2.7 × 10-12 J = eV = 17.35 × 106 eV = 17.35 MeV

1. **Explain the historical significance of this experiment.**

Verified 𝑬=𝒎𝒄𝟐/ first transmutation by an artificially accelerated particle / important step in development of the particle accelerator / Nobel prize

(b)

1. Draw a diagram to show the basic structure of the bi-polar transistor.
2. State the relationship between the three currents flowing in a transistor circuit.

𝑰𝑬= 𝑰𝑩+𝑰𝑪

1. Draw the circuit diagram for a transistor circuit that can be used as a voltage inverter (NOT gate).
transistor and resistor in series

collector connected to positive, emitter connected to earth

correct input indicated

correct output indicated

1. Draw the truth table for a NOT gate.

input = 0, output = 1

input = 1, output = 0