**2010 Leaving Cert Physics Solutions (Higher Level)**

1.

[2010]

In an experiment to investigate the relationship between the acceleration of a body and the force applied to it, a student recorded the following data.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *F*/N | 0.20 | 0.40 | 0.60 | 0.80 | 1.00 | 1.20 | 1.40 |
| *a*/m s–2 | 0.08 | 0.18 | 0.28 | 0.31 | 0.45 | 0.51 | 0.60 |

1. **Describe the steps involved in measuring the acceleration of the body.**

Measure/calculate the initial velocity/speed

Measure/calculate the velocity/speed again (t seconds later)

Measure time interval from initial to final velocities / distance between light gates

Use relevant formula

Datalogging method:

Align motion sensor with body (e.g. trolley) / diagram

Select START and release body

(Select STOP and) display GRAPH of ‘*a* vs. *t*’ // ‘*v* vs. *t*’

(Use tool bar to) find average value for *a* // use slope (tool) to find *a (*= *dv /dt)*

1. **Using the recorded data, plot a graph to show the relationship between the acceleration of the body and the force applied to it.**

Label axes correctly on graph paper

Plot six points correctly

Straight line

Good distribution

1. **What does your graph tell you about this relationship?**

Acceleration is proportional to the applied force.

1. **Using your graph, find the mass of the body.**

 The mass of the body corresponds to the slope of the graph = 2.32 kg [range: 2.1 - 2.4 kg]

1. **On a trial run of this experiment, a student found that the graph did not go through the origin.**

**Suggest a reason for this and**

Friction / dust on the track slowing down the trolley.

1. **Describe how the apparatus should be adjusted, so that the graph would go through the origin.**

Elevate/adjust the track/slope

2.

[2010]

In an experiment to measure the specific latent heat of vaporisation of water, a student used a copper calorimeter containing water and a sensitive thermometer. The water was cooled below room temperature before adding dry steam to it. The following measurements were recorded.

Mass of copper calorimeter = 34.6 g

Initial mass of calorimeter and water = 96.4 g

Mass of dry steam added = 1.2 g

Initial temperature of calorimeter and cooled water = 8.2 °C

Final temperature of calorimeter and water = 20.0 °C

1. **How was the water cooled below room temperature?**

Ice was added to the water / the water was taken from fridge

1. **How was the steam dried?**

By using a steam trap (or ensure that the delivery tube is sloped upwards)

1. **Describe how the mass of the steam was determined.**

Final mass of calorimeter plus contents – initial mass of calorimeter and contents

1. **Why was a sensitive thermometer used?**

For greater accuracy / to reduce (%) error / more significant figures / e.g. to read to 0.1 oC

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

ms = 1.2×10-3 kg and

mw = 6.18 × 10-2 kg

Δθs = 80 (K) and

Δθw (= Δθcu) = 11.8 (K)

[heat lost by steam = heat gained by water and calorimeter]

 (ml)s + (*mc*Δθ )s = (*mc*Δθ )w + (*mc*Δθ )cu

(1.2×10-3)l + (1.2×10-3)(4180)(80) = (6.18 × 10-2)(4180)(11.8) + (3.46 × 10-2)(11.8)(390)

(1.2×10-3)l + 401.3 = 3048.2 + 159.2

l = 2.34 × 106 J Kg-1

3

[2010]

In an experiment to verify Snell’s law, a student recorded the following data.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *i* / ° | 30 | 40 | 50 | 55 | 60 | 65 | 70 |
| *r* / ° | 19 | 26 | 30 | 33 | 36 | 38 | 40 |

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

**On your diagram, indicate an angle *i* and its corresponding angle *r*.**

Diagram to show:

A target medium e.g. glass block

Incident ray (from ray box)

Perpendicular / normal and refracted ray

Label angles *i* and *r*

1. **Using the recorded data, draw a suitable graph**

Correct sin *i* and sin *r* values for six points

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| sin *i*  | 0.500 | 0.643 | 0.766 | 0.819 | 0.866 | 0.906 | 0.939 |
| sin *r* | 0.325 | 0.438 | 0.500 | 0.544 | 0.588  | 0.615 | 0.643 |

Label axes correctly on graph paper

Plot six points correctly

Straight line showing good distribution

1. **Explain how your graph verifies Snell’s law.**

A straight line through the origin shows that sin *i* is proportional to sin *r*

1. **Using your graph, find the refractive index**

Correct slope method

(*n* = ) 1.41 [range: 1.38 – 1.52]

1. **The student did not record any values of *i* below 30°, give two reasons why?**

To reduce the (percentage) error

Elaboration e.g. difficult to measure /read angles, *r* < *i* , etc.

4

[2010]

In an experiment to investigate the variation of the resistance *R* of a thermistor with its temperature *θ*, a student measured its resistance at different temperatures.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *θ* /°C | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| *R*/Ω | 2000 | 1300 | 800 | 400 | 200 | 90 | 40 |

The table shows the measurements recorded.

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

Thermistor, thermometer in waterbath/oil, thermistor connected to *labelled* ohmmeter/(digital) multimeter

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

The thermistor is connected to the ohmmeter and the value of the resistance was read from the ohmmeter.

1. **Describe how the temperature was varied.**

By allowing the apparatus to heat up over **a** bunsen burner.

1. **Using the recorded data, plot a graph to show the variation of the resistance of a thermistor with its temperature.**

Label axes correctly on graph paper

Plot six points correctly

Smooth curve

Good distribution

1. **Use your graph to estimate the average variation of resistance per Kelvin in the range 45 °C – 55 °C.**

Range: 28↔ 32 Ω (0C–1) or Ω (K–1)

1. **In this investigation, why is the thermistor usually immersed in oil rather than in water?**

Oil is a better conductor of heat / water contains air / (impure) water conducts electricity/good thermal contact

**2010 Question 5**

1. **What are the two conditions for the equilibrium of a set of co-planar forces?**

Forces up = forces down // Algebraic sum of forces acting is zero

(Algebraic) sum of the moments (of the forces about any point) is zero

1. **What is the critical angle of a sample of glass whose refractive index is 1.46?**

 C = C = 43.2o



1. **Name the parts labelled A and B of the spectrometer shown in the diagram.**

A = Turntable, B = telescope

1. **Explain why snow is slow to melt as the day-time temperatures rises above 0 °C.**

Latent heat of snow/ice (energy needed for change of state) is (very) large

1. **What is the positive charge stored on a 5 μF capacitor when connected to 120 V d.c. supply?**

 Q = CV Q= (5 × 10–6)(120)Q = 6.0 × 10–4 C

1. **Which of the following devices is adjusted when tuning into a radio station?**

**Transformer, diode, capacitor, rheostat**

Capacitor

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 flux.

1. **The peak voltage of an a.c. supply is 300 V. Calculate its rms voltage.**

Vrms = = = 212 V

1. **Name the naturally occurring radioactive gas which seeps into buildings from underground rocks and which can cause lung cancer.**

Radon gas

1. **Give two advantages of a circular accelerator over a linear accelerator.**

Smaller (less space) // greater speeds/energy

or

**State the principle of a moving-coil galvanometer.**

A current carrying conductor experiences a force when placed in a magnetic field.

**2010 Question 6**

1. **State Newton’s law of universal gravitation.**

Force between any two point masses is proportional to product of masses and inversely proportional to square of the distance between them.

1. **Use this law to calculate the acceleration due to gravity at a height above the surface of the earth, which is twice the radius of the earth.**

Here we will use the relationship 

This looks like we need to know the mass of the Earth to calculate *g*, but we can actually do this without knowing the mass of the Earth.

*Note that 2d above surface is 3d from earth’s centre*

*g* is proportional to
This means that if *d* goes up by a factor of 3 (gets 3 times bigger), *g* will go down by a factor of 9 (gets 9 times *smaller*)

 gnew = 1.09 m s-2

1. **Explain why the spacecraft continues on its journey to the moon, even though the engines are turned off.**

There are no external forces acting on the spacecraft so from Newton’s 1st law of motion the object will maintain its velocity.

1. **Describe the variation in the weight of the astronauts as they travel to the moon.**

Weight decreases as the astronaut moves away from the earth and gains (a lesser than normal) weight as she/he approaches the moon

1. **At what height above the earth’s surface will the astronauts experience weightlessness?**

Gravitational pull of earth = gravitational pull of moon

d1 = distance between astronaut and the Earth

d2 = distance between astronaut and the Moon

m = mass of astronaut

 = 

Cancel G and m on both sides and rearrange to get  

d1 = 9d2

Note also that d1 + d2 = distance between the Earth and the Moon = 3.84 × 108 m

9d2 + d2 = distance between the Earth and the Moon = 3.84 × 108 m

10 d2 = 3.84 × 108 d2 = 3.84 × 107 d1 = 3.356 × 108

Height above the earth = (3.356 × 108) – (6.36 × 106) = 3.39 × 108 m

1. **The moon orbits the earth every 27.3 days. What is its velocity, expressed in metres per second?**

v = 1022.9 m s-1

1. **Why is there no atmosphere on the moon?**

The gravitational force is too weak to sustain an atmosphere.

**2010 Question 7**

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

The Doppler effect is the apparent change in frequency due to the relative motion between a source and an 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:

1. 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.
2. Behind the moving source, the crests are further apart than crests from the stationery source would be.
3. This means the wavelengths are greater and therefore the frequency is less.
4. **Describe a laboratory experiment to demonstrate the Doppler effect.**

Attach a string to a buzzer.

Swing the buzzer over your head.

An observer will note a frequency change as the buzzer approaches then recedes from the observer.

1. **What causes the red shift in the spectrum of a distant star?**

Distant stars are moving away from us therefore the wavelengths increase.

1. **What can you deduce about the motion of the star?**

The star is moving away from earth

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

f = = f = 5.11073× 1014

f’ = = f’ = 5.08475× 1014

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



 1.533219

1.525425 1.533219

7.794 =

 Answer: u = 1.5333 × 106 m s-1

1. **Give another application of the Doppler effect.**

Radar, medical imaging, blood flow measurement (echocardiogram), temperature measurement, (underwater) acoustics, etc.

**2010 Question 8**

1. **What is an electric current?**

An electric current is a flow of charge

1. **Heating is one effect of an electric current. Give two other effects of an electric current.**

Magnetic and chemical

1. **Describe what happens when switch A is closed and the rheostat is adjusted**

The fan operates and its speed of rotation changes.

1. **Describe what happens when switch A and switch B are closed.**

Current flows through coil and the coil gets hot.

The fan blows hot air

1. **Calculate the current that flows through the coil when the dryer is turned on.**

P = VI

I = = I = 8.7 A

1. **The maximum power generated in the heating coil is 2 kW.**

 What is the initial resistance of the coil?

V = RI

R = = 26.4 Ω

1. **A length of nichrome wire of diameter 0.17 mm is used for the coil.**

Calculate the length of the coil of wire.

A = πr2

A = (3.14)(0.085 × 10-3)2

A = 2.27 × 10-8 m2

ρ = *l* = *l* = *l* = 0.545 m

1. **Explain why the current through the coil would decrease if the fan developed a fault and stopped working.**

The coil gets hot therefore its resistance increases

**2010 Question 9**

1. **What is thermionic emission?**

It is the emission of electrons from the surface of a hot metal due to electromagnetic radiation of a suitable frequency falling upon it.

1. **Draw a labelled diagram of an X-ray tube.**
2. **What are X-rays?**

X-rays are electromagnetic radiation of high frequency / short wavelength

1. **How do they differ from light rays?**

X-rays have a higher frequency / penetrate matter / cause ionization.

1. **Give two uses of X-rays.**

(Medical) analysis of bone structure/ luggage scanners (at airports) / any ***specific*** medical,industrial or security use, etc.

1. **When electrons hit the target in an X-ray tube, only a small percentage of their energy is converted into X-rays. What happens to the rest of their energy.**

The energy gets converted to heat.

1. **How does this influence the type of target used?**

The target material must have very high melting point.

1. **A potential difference (voltage) of 40 kV is applied across an X-ray tube.**

**Calculate the maximum energy of an electron as it hits the target.**

W = QV

W = (1.6 × 10-19)( 40 × 103)

W = 6.4 × 10-15 J

1. **Calculate the frequency of the most energetic X-ray produced.**

E = hf *f* = 9.7 × 1018 Hz

**2010 Question 10 (a)**

1. **What is anti-matter?**

Antimatter is material/matter/particles that has the same mass as another particle but opposite charge.

1. **Name the anti-particle and give its symbol.**

positron / anti-electron

1. **What happens when a particle meets its anti-particle?**

Pair annihilation occurs and the mass gets converted to energy.

1. **What is meant by pair production?**

 Pair production involves the production of a particle and its antiparticle from a gamma ray photon.

1. **Calculate the kinetic energy of one of the particles produced, each of which has a rest mass of 9.1 × 10–31 kg.**

Energy of incident photon = energy required to create 2 particles + kinetic energy of particles

Energy of incident photon = *hf* E = (6.6 × 10-34)( 3.6 × 1020) = 2.376 × 10-13 J

Energy required to produce the *two* particles = 2[mc2]

E = 2(9.1 × 10-31)(3.0 × 108)2 = 1.638 × 10-13 J

Energy of incident photon = energy required to create 2 particles + kinetic energy of particles

2.376 × 10-13 J = 1.638 × 10-13 J + kinetic energy

Extra energy available for kinetic energy = (2.376 × 10-13) – (1.638 × 10-13) = 7.38 × 10-14

Kinetic energy *per particle* is half of this = 3.69 × 10-14 Joules

1. **Construct the possible combinations.**

**Deduce the charge of each combination and identify each combination.**

|  |  |  |
| --- | --- | --- |
| **composition** | **charge** | **name** |
| u  |  | 0 | Pi-neutrino |
| u  |  | +1 | Pi-plus |
| d  |  | -1 | Pi-minus |
| d  |  | 0 | Pi-neutrino |
|  |  |  |  |

1. **What famous Irish writer first thought up the name ‘quark’?**

(James) Joyce

**2010 Question 10 (b)**

1. **Distinguish between intrinsic conduction and extrinsic conduction in a semiconductor.**

Intrinsic conduction occurs in a pure semiconductorand involves an equal number of electrons and (positive) holes.

Extrinsic conduction occurs in a doped semiconductor where either the electrons or the positive holes are the majority charge carriers.



1. **The circuit shows four light-emitting diodes connected to a resistor *R* and a 6 V a.c. supply of frequency 1 Hz.**

**What is observed when the circuit is operating?**

During one second/cycle D1 and D4 flash (together during one half cycle) followed by D2 and D3.

1. **Explain what is observed by referring to the circuit.**

When D1 and D4 are forward biased (and so they will conduct) D2 and D3 are reverse biased

1. **What is observed when the frequency of the a.c. supply is increased to 50 Hz?**

The diodes flash so fast that the leds appear to light continuously

1. **Give two functions of the resistor R.**

It protects the leds from over-load and also limits the current (acts as a load resistor).

1. **How was the output voltage displayed?**

Using a cathode ray oscilloscope or datalogger.

1. **Draw graphs to show the differences between the input voltage and the output voltage.**

There is an a.c input and an in phase fully rectified output.

1. **It is noticed that the output voltage is lower than the input voltage. Explain why.**

There is a voltage drop across a led ( ≈1.6 V).

**2010 Question 11**

1. **Give two properties of radio waves.**

They travel at speed of light, electromagnetic radiation, travel through vacuum, can be reflected, refracted, polarized etc.

1. **Calculate the SAR value.**

*While there is nothing about SAR values in the syllabus, all the information we need to work with is given in the question. We are told that that the units of SAR are watts per kilogram. So*

*So first we need to calculate the power.*

 = 0.002 W

 = = = 0.20 W kg-1

1. **What happens to the radio frequency energy absorbed by the body?**

It is converted into heat in the body.

1. **Why are radio frequency waves not very penetrating?**

They have a low frequency / long wavelength / low energy.

1. **What are the audible frequency limits for sound waves?**

20 Hz to 20 000 Hz

1. **Give two safety precautions you should take when using a mobile phone.**

Keep phone at distance, use loudspeaker function, ‘no hands, brief calls only, direct antenna away from your head etc.

1. **Calculate the length of its antenna, which is one quarter of the wavelength that it transmits.**

*f* = 1200 MHz = 1200 × 106 Hz = 1.2 × 109 Hz

 = λ = 0.25 m

Length of antenna = ¼ of the wavelength = = 0.0625 m.

1. **Name an electromagnetic wave which may induce cancer. Justify your answer.**

Gammarays / X-rays / UV - they can all cause ionization of body cells.

**2010 Question 12 (a)**

1. **List the instructions you should give the student . . .**

Stand 1 m from wall (and select *START*)

Stay stationary for 5 s

Move back to 3 m (from wall) over the next 6 s

Stationary for 7 s

Approach to 1 m over the next 4 s

1. **The graph in Figure 2 represents the motion of a cyclist on a journey.**

**Using the graph, calculate the distance travelled by the cyclist and the average speed for the journey.**

The Y-axis (speed) is km h-1 and the X-axis (time) is in minutes so we need to make convert from km h-1

to m s-1 on the Y-axis, and from minutes to seconds on the X-axis

18 km h-1 = = 5 m s-1

6 min = 360 secs

14 mins = 840 secs

19 min = 1140 secs

We can use the fact that the area under the graph corresponds to the distance travelled:

Section 1 = half the base multiplied by the height = 180 × 5 = 900 m

Section 2 = base multiplied by the height = 480 × 5 = 2400 m

Section 3 = half the base multiplied by the height = 150 × 5 = 750 m

Total distance = 900 + 2400 + 750 = 4050 m

Total distance = 4050 m

 = = 3.55 m s-1

**2010 Question 12 (b)**

1. **Identify the element X.**

*We use log tables (page 79) to identify the number at the bottom for barium (Ba): 56*

*We use log tables (page 82) to identify the number at the bottom for uranium (U): 92*

*The total number on the bottom of the left (92) must equal the total number on the bottom of the right.*

92 – 56 = 36

*We then go back to the log tables (page 79) to ding out what element has an atomic number of 36.*

Answer: Krypton (Kr)

1. **Calculate the mass difference between the reactants and the products in the reaction**

The kinetic energy of 202.5 MeV came from the mass that ‘disappeared’. So we can use E = mc2 to work backwords and find out the missing mass.

First we need to convert 202.5 MeV to Joules by using the fact that 1 eV = Joules

202.5 MeV = = 3.24 × 10-11 Joules

 m = 3.6 × 10-28 kg

1. **What is a chain reaction?**

It is a self-sustaining reaction where fission neutrons go on to produce further fission(giving more neutrons) etc.

1. **Give one condition necessary for a chain reaction to occur.**

The mass of fuel present must exceed the critical mass / at least one of the neutrons releasedmust cause fission of another nucleus.

1. **Give one environmental impact associated with a nuclear reactor.**

Toxic /radioactive waste, exposure to radiation, etc.

**2010 Question 12 (c)**

1. **Explain the term resonance and describe a laboratory experiment to demonstrate it.**

Resonance is the transfer of energy so that a body vibrates at its natural frequency.

**To Demonstrate Resonance**

* Use two ***identical*** tuning forks (same frequency) and a sound-board.
* Start one fork vibrating, place it on the sound-board and notice the sound.
* Place the second tuning fork on the sound-board and then stop the first tuning fork from vibrating.
* The second fork can now be heard.
*NB: you must make reference to the fact that both tuning forks are of the same frequency*
1. **Give two characteristics of a musical note and name the physical property on which each characteristic depends.**

Pitch: frequency

Loud: amplitude / intensity

Quality: number of harmonics and their relative strengths

1. **Explain why a musical tune does not sound the same when played on different instruments.**

Different instruments emit a fundamental frequency plus different combinations of overtones/harmonics.

**2010 Question 12 (d)**

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

Electric field strength is defined as force per unit charge.

Its unit is the N C–1 (or V m-1)

1. **Copy the diagram into your answerbook and show on it the direction of the electric field at point P.**

Answer:

Electric field strength is defined in part as the field acting on a unit *positive* charge.



1. **Calculate the electric field strength at P.**

The electric field strength at P is the sum of the electric fields acting on P from the other two charges. The electric field strength is towards the left in both cases (attracted to the negative charge and repelled from the positive charge).

Because both electric fields are in the same direction (towards the left) the individual field strengths can simply be added together.

Etotal = 3.77 × 106 N C-1

1. **Under what circumstances will point discharge occur?**

High charge density at a point / large electric field strength /potential at a point