**2019 Leaving Cert Physics Solutions (Higher Level)**

**2019 Question 1**

1. **Draw a labelled diagram of the apparatus used in the experiment.**      
   timer, ball and release mechanism, pressure plate
2. **Between which points was the distance *s* measured**?

From bottom of ball to top of pressure plate

1. **Describe how the time *t* was measured.**  
   timer started when ball released and stopped when it hit plate
2. **Draw a suitable graph that can be used to determine the acceleration due to gravity *g*.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *s* (cm) | 30.0 | 40.0 | 50.0 | 60.0 | 70.0 | 80.0 | 90.0 |
| *t* (ms) | 250 | 285 | 310 | 345 | 380 | 400 | 435 |
| *s* (m) | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| *t* 2 (s2) | 0.063 | 0.081 | 0.096 | 0.119 | 0.144 | 0.160 | 0.189 |

values for *t* 2

labelled axes (3)

points plotted

straight line of good fit

1. **Hence determine *g*.**    
   slope formula / correct substitution into slope formula

slope calculated: slope

acceleration due to gravity calculated: slope ≈ 10 m s-2

1. **A small, dense ball was used as the object in this experiment.  State an advantage of using this type of ball.**  
   less air resistance

**2019 Question 2**

1. **How did the student find the approximate focal length?**  
   found image of a distant object
2. **Why did the student find the approximate focal length at the start of the experiment?**  
   to ensure object was placed outside of focal point / so a real image could be formed / image formed on a screen / to compare with later answer
3. **Describe, with the aid of a labelled diagram, how the position of the image was found.**  
   concave mirror, screen and object

correct arrangement

move screen (and/or object and/or mirror) until (sharpest) image is formed

1. **State two precautions that should be taken when measuring *v*.**  
   error of parallax, measure to back of mirror, measure to centre of mirror, sharp image formed
2. **Use all of the data to calculate the focal length of the mirror.**

values of *f*: 15.1, 14.9, 15.0, 14.5 cm

average: 14.9 cm

**2019 Question 3**

In an experiment to determine the specific latent heat of fusion of ice, a student first crushed some ice.

She then dried the melting ice before adding it to warm water in an insulated copper calorimeter.

The following data were recorded.

Mass of copper calorimeter = 56.3 g

Mass of calorimeter and water before adding ice = 108.5 g

Initial temperature of water = 29.5 °C

Final temperature of water = 8.0 °C

Mass of calorimeter and water after adding ice = 122.9 g

1. **Why did the student crush the ice?**  
   to ensure it was all at the same temperature / to ensure it was all at 0°C / so that it would melt faster / to give a greater surface area
2. **Why did the student dry the ice?**  
   to ensure that only ice was added to the calorimeter
3. **How was the ice crushed?**  
   e.g ice crusher
4. **How was the ice dried?**  
   using a towel
5. **Why did she use warm water?**  
   ice would melt more quickly / so that energy lost = energy gained
6. **Why did she use melting ice?**  
   to ensure that the ice was at 0°C
7. **Use the data to calculate the specific latent heat of fusion of ice.**

∆θ*ice* = 8, ∆θ*water* = 21.5, *mwater* = 52.2 grams

*ml* + (*mc∆θ*)*water =* (*mc∆θ*)water + (*mc*∆*θ*)calorimeter

(14.4)*l*ice + (14.4)(4180)(8) = (52.2)(4180)(21.5) + (56.3)(390)(21.5)

*l*ice = 3.25 105 J kg-1

1. **Why could using a very large mass of water lead to a less accurate result in this experiment?**  
   smaller change in temperature / greater percentage error

**2019 Question 4**

1. **Draw a circuit diagram for this experiment.**  
   source of varying voltage, diode, ammeter, voltmeter

correct arrangement

1. **Use the data to draw a graph of current against potential difference.**  
   labelled axes

points plotted

curve of good fit

1. **Use your graph to determine the junction voltage.**  
   ≈ 0.2 V
2. **What happened in the diode when the junction voltage was exceeded?**  
   depletion layer broke down / low resistance / current flows
3. **Is Ohm’s law obeyed for the diode? Justify your answer.**  
   no

not a straight line through the origin

1. **State two other changes that are made to the circuit before recording data for a diode in reverse bias.**  
   replace ammeter with a microammeter,

place voltmeter across diode and (micro)ammeter,

remove (protective) resistor if already included

**2019 Question 5**

1. **Calculate this distance in metres.**  
    *s* = *vt*

*s* = (3.00 × 108)(3.15 × 107)  
s = 9.45 × 1015 m

1. **Calculate the density of the apple.**   
   *W* = *mg m* = 0.102 kg  
    = 843 kg-3
2. **Draw a labelled diagram to show the forces acting on the book as it moves on the table.**  
   force up

(equal) force down (vectors should be of equal size)

net horizontal force to the left

1. **What is meant by polarisation of light?**  
   the wave is vibrating in one plane only
2. **What is the thermometric property of (i) a mercury thermometer, (ii) a thermocouple?**  
   i) length/height/volume

(ii) emf/voltage

1. **Sketch a graph to show the relationship between resistance *R* and temperature *T* (in °C) for a metallic conductor.**  
   labelled axes

straight line (not going through the origin)

1. **Write *P* in terms of *R* and *V*.**  
   *P = VI* (use *I = V/R*)   
   *P = V2/R*
2. **Calculate the activity of a sample of polonium–218 that contains 75000 nuclei.**  
    = 0.00385  
     
   A = = (0.00385)(75000) = 289 Bq
3. **Write a nuclear equation for this reaction.**
4. **Neutrinos are sometimes called ghost particles. Why are they very hard to detect?**  
   very small mass

no charge

**2019 Question 6**

1. **State Newton’s law of universal gravitation.**  
   Force is proportional to product of masses and inversely proportional to distance squared

Or equation plus notation

1. **What is the relationship between the period *T* and radius of orbit *r* of a satellite?**  
   T2  R3
2. **Which has a longer wavelength, visible or infrared radiation?**   
   infrared
3. **Describe how infrared radiation can be detected in the school laboratory.**  
   heating effect / thermometer
4. **What is the period of METEOSAT 11?**  
   24 hours
5. **Calculate its height above the surface of the Earth.**

R = 42400000 m

we need to subtract the radius of the earth from R to calculate the height of the satellite above the earth.

*h* = (R – Rearth)

*h* = (42400000 – 6400000) = 3.596 × 107 m = 35960000 m = 36000 km

1. **Calculate its radius of orbit.**convert 14000 km hr‐1 to m s-1 = 14000000/(3600) = 3889 m s-1

R = 2.65 107 m

1. **Calculate its angular velocity.**

3889 = (2.65 × 107)(ω)  
ω = 1.47 × 10-4 rad s-1

1. **Calculate the minimum time it takes a signal to travel from the global positioning satellite to the Earth.**

*t* = 0.067 s

1. **Explain why satellites remain in orbit and do not fall to Earth.**  
   I have a love/hate relationship with this question. It really requires an essay and even then you have to decide at what level to pitch the answer. I *think* I know the answer but it’s too long to go into here (and you can check out different explanations on the *circular motion* webpage on *thephysicsteacher.ie*), so let’s just go with the marking scheme answer: ‘(horizontal) velocity’.

**2019 Question 7**

1. **What is meant by potential difference**?   
   This is the work done when a charge of 1 coulomb is accelerated from one point to another.
2. **State its unit.**  
   The volt.
3. **Define electric field strength.**  
   Force per unit charge
4. **Describe how an insulated spherical conductor can be charged positively by induction.**  
   Bring a negatively charged rod close to the spherical conductor

earth sphere ***then*** remove earth ***then*** remove the charged rod

1. **Draw the electric field around the charged conductor.**  
   radial field lines away from positive charge
2. **Calculate the charge on the conductor.**  
   Remember that ‘d’ in this context refers to the distance from ***the*** ***center*** ***of the sphere*** to a point 5 cm from the surface (6 cm + 5 cm) = 0.11 m  
     
    Q = 3.1 × 10-12 C
3. **Explain how point discharge occurs.**  
   charge accumulates at a point

air around point is ionised

opposite charges attracted / like charges repelled

1. **Describe how point discharge can be demonstrated in the laboratory.**  
   charged point

candle at point

flame is blown away from the point

**2019 Question 8**

1. **Distinguish between photoelectric and thermionic emission.**  
   photoelectric: light; thermionic: heat
2. **What name is given to electrons emitted during radioactive decay?**  
   beta
3. **What is a line emission spectrum?**   
   (specific) frequencies/colours (of e.m. radiation) emitted by a material
4. **Explain, in terms of the structure of the atom, how this spectrum is produced.**  
   energy given to electron

electron changes energy levels

photon emitted / light emitted / (e.m.) radiation emitted

1. **Write down Einstein’s photoelectric equation.**  
   h*f* = + ½*mv*2
2. **What physical quantity is represented by point A?**  
   threshold frequency
3. **What physical quantity is represented by the slope of the graph?**   
   Planck constant (fair play to you if you got that right – it definitely wasn’t specified on the syllabus)
4. **Calculate the maximum velocity of the emitted electrons when photons of energy 4.15 eV are incident on magnesium.**  
   *Ek* = 0.47 eV = 7.5 × 10-20 J *Ek* = ½ *mv*2 = 7.5 × 10-20

7.5 × 10-20 = ½ (9.1 × 10-31)*v*2 *v* = 4.1 × 105 m s-1

1. **Electrons are produced in an X‐ray tube by thermionic emission.**

Where in the tube are the electrons produced?

1. **What is the minimum wavelength of an X‐ray produced in a 50 kV tube?***eV = hf*(1.6 × 10-19)(50 × 103) = (6.6 × 10-34)*f  
     
   f* = 1.2 1019 Hz Now use *c = f* to find the wavelength

× 10-11 m

1. **State two design features of an X‐ray tube that take account of this.**  
   tungsten target, cooling fluid

**2019 Question 9 (a)**

1. **Explain the underlined terms.**  
   Force is what causes acceleration

Magnetic field is a region where magnetic forces are felt

1. **Describe an experiment to demonstrate that a current‐carrying conductor experiences a force in a magnetic field.**  
   power supply, aluminium foil, magnets   
   correct arrangement   
   foil moves
2. **When would a current‐carrying conductor in a magnetic field not experience a force?**  
   it is parallel to the field

**2019 Question 9 (b)**

1. **Write down an expression for the force *F* on the current‐carrying wire in terms of *I*, *B* and the length *l* of the wire.**  
   *F = BIL*
2. **Plot a graph on graph paper of force against current.**  
   labelled axes  
   points plotted correctly

line of good fit

1. **Calculate the slope of the graph and use it to calculate the magnetic flux density of the field.**  
   Plot a graph of B against I (*F* on *y*-axis and *I* on x-axis)  
   *Begin by rearranging F = BIL* to the form *F =* (*BL*)*I*  
     
   Compare *F =* (*BL*)I to *y = mx* slope corresponds to *BL*  
   slope = 0.02

0.02 = B(0.03) B = 0.67 T

**2019 Question 9 (c)**

1. **Derive the expression *F* = *qvB***  
   *F = BIL*  
    and   
     
   F = B *F = qvB*
2. **Calculate the speed of the proton as it enters the field.**  
   *F = qvB*   
    *qvB =   
     
   (*1.60× 10-19)(0.5) = *v* = 1.1 × 105 m s-1

**2019 Question 10**

1. **Explain the terms diffraction and interference.**   
   diffraction: the spreading out of a wave after it passes an obstacle/gap

interference: occurs when two waves meet

1. **Explain, with the aid of a labelled diagram, how a series of bright and dark fringes were produced.**  
   slits

diffraction at slits   
interference

1. **How does this experiment demonstrate that light is a wave?**result can only be explained using interference
2. **Calculate the wavelength of the monochromatic light.**  
   distance between zero order imagine and sixth order image = 0.825 cm  
     
    = 0.378 *d* = 0.5 × 10-3 m  
   *nλ = d Sin θ 6λ =* (0.5× 10-3)Sin(0.378) *λ =* 5.5 ×10-7m
3. **List two adjustment to the apparatus that could be made to increase the distance between the bright fringes.**   
   move screen from slits, decrease distance between slits, increase *λ*
4. **What effect does this have on the power of the lens?**   
   decreases power
5. **Draw diagrams to show the first two harmonics of this instrument.**   
   correct diagram for first harmonic

correct diagram for third harmonic

1. **Calculate the wavelength of the sound wave.**  
   *λ =* 2 × (0.498 – 0.167) = 0.66 m
2. **Calculate the speed of sound in air.**  
   *c = fλ* c = (512)(0.66) = 339 m s-1

**2019 Question 11**

1. **Explain why the transmission of electricity using low voltage is not economical.**  
   low voltage implies high current

High current results in more heat/energy loss than low current.

1. **Name the device used to (i) reduce a.c. voltage, (ii) convert current from a.c. to d.c.**  
   (i) transformer

(ii) rectifier/diode

1. **State Hooke’s law.**  
   Restoring force is proportional to displacement

Or *F = - k s* with correct notation

1. Use Newton’s laws of motion to calculate the force exerted by the wall on the ball.

F = 4.4 N

1. **Draw a ray diagram to show the formation of an upright image in a magnifying glass.**  
   object inside focal point of converging lens

two correct rays through lens

correct image

1. **Write a nuclear equation for this fission reaction.**
2. **Calculate the energy released in this reaction.**  
   Begin by writing the mass of each element in terms of *u*.   
   Then subtract the total on the right hand side from the total on the left hand side.  
   Then convert back from *u* to kg.  
     
   loss in mass = 3.3682 × 10-28 kg  
   *E = mc*2

*E* = (3.3682 × 10-28)(2.9979 × 108)2 = 3.0271 × 10-11 J

1. **In what form is this energy released?**  
   kinetic energy / heat

**2019 Question 12 (a)**

1. **State the principle of conversation of energy.**  
   Energy cannot be created or destroyed but can only be converted from one form to another.
2. **Calculate the velocity of the mass at position B**  
   *h* = 0.8 – 0.8 *h* = 0.145 m  
    *Total energy at the bottom = total energy at point B  
    mgh* + ½ *mv*2 = *mgh* + ½ *mv*2 {cancel m from each term}  
    0 + ½(4)2 = (9.8)(0.145) = ½*v*2  
    *v* = 3.63 m s-1
3. **Calculate its centripetal acceleration at position B.**  
    = 16.5 m s-2 (towards the center)
4. **Draw a labelled diagram to show the forces acting on the mass when it is at position B.**  
   weight acting downwards, tension acting towards the center

**2019 Question 12 (b)**

1. **What is a semiconductor?**  
   material with a resistivity between that of a conductor and an insulator
2. **What is meant by doping a semiconductor?**  
   adding an impurity (to change its conductivity)
3. **How can a semiconductor be doped so that its majority charge carriers are electrons?**  
   add an element with more outer electrons / add e.g. phosphorus
4. **How can a semiconductor be doped so that its majority charge carriers are holes?**  
   add an element with fewer outer electrons/ add e.g. boron
5. **Calculate the energy stored in the capacitor when it is fully charged.**  
   W = ½ CV2 W = ½ (90 × 10-15)(1.2)2 W = 6.5 × 10-14 J
6. Calculate the number of additional electrons that are on the negative plate of the capacitor as a result of it being fully charged.  
   Q = CV Q = (90 × 10-15)(1.2) Q = 1.08 × 10-13 C

**2019 Question 12 (c)**

1. **Explain the underlined terms.**  
   Critical angle: angle of incidence corresponding to an angle of refraction of 90°

total internal reflection: Angle of incidence > critical angle and all light is reflected back

1. **Calculate the area of this disc of light.**  
   The formula for area of a disc is πr2, so we need a value for *r*.

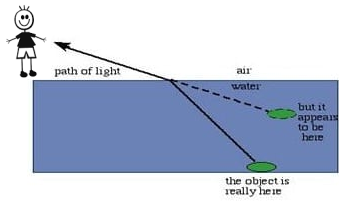
First we can calculate a value for the critical angle *C* using

ic = 48.80

If we know C and the depth of the diver (12 m), then we can use trigonometry to work out *r*.

*r* = 12 tan C *r* = 13.7 m Area = πr2 = π(13.7)2

Area = 590 m2

1. **Use a labelled diagram to explain why the diver does not appear to be at a depth of 12 m when viewed by an observer outside the pool.**  
   correct refracted ray

**2019 Question 12 (d)**

1. **Name the two families and distinguish between them.**

baryon and meson  
baryon has three quarks and meson has a quark and an antiquark

1. **The single pion produced must be neutral.  Explain why.**   
   For charge to be conserved.
2. **Calculate the total kinetic energy of the three particles after the collision.**

Total kinetic energy of the 3 particles after = (kinetic energy beforehand) – (energy required to produce the pion)

**Step 1: Calculate the kinetic energy beforehand**

Mass of proton = 1.6726×10-27 kg {mass of proton available from page 47 of F&T booklet}

J

**Step 2: Calculate the energy required to produce the pion.**

Energy to produce the pion: Use E = mc2, where m represents the mass of the pion in kg.

Mass of π0 = (264)(mass of one electron) {relative mass of π0 available from page 48 of F&T booklet}

Mass of π0 = (264)(9.1094 × 10-31 kg) {mass of electron available from page 47 of F&T booklet}

Mass of π0 = 2.4048816×10-28 kg

Energy to produce the pion = mc2 = (2.4048816×10-28)(2.9979 ×108)2 = 2.1614×10-11 J

Energy of the 3 particles after = (kinetic energy beforehand) – (energy required to produce the pion)

Energy of the 3 particles after =) – (2.4048816×10-28)(2.9979 ×108)2

Energy of the 3 particles after =) – 2.1614×10-11

Energy of the 3 particles after = 1.00 ×10-10 J

1. **How are the protons maintained in circular motion?**   
   Using magnetic fields
2. **State the principal advantage of a circular accelerator over a linear accelerator.**   
   “Greater energy can be created”  
   The line above is taken straight from the official Marking Scheme. Which isn’t overly reassuring when one considers that the answer to the first part of Question 12 (a) is that *energy* cannot be created. I suppose it just highlights how difficult it is to be precise with the phrases we used. We all ‘know’ what we are trying to say when we use phrases incorrectly like this, and usually that’s good enough. I suppose the other thing to consider is that the Marking Scheme isn’t saying that they necessarily approve of this answer; just that they were prepared to award it full marks in this instance.  
   A better answer would be along the following lines: “So that a greater amount of energy can be transferred to the accelerating particles”.