**LEAVING CERTIFICATE EXAMINATION 2002: PHYSICS – HIGHER LEVEL**

1

A student investigated the laws of equilibrium for a set of co-planar forces acting on a metre stick.

The weight of the metre stick was 1 N and its centre of gravity was found to be at the 50.5 cm mark.

Two spring balances and a number of weights were attached to the metre stick.

Their positions were adjusted until the metre stick was in horizontal equilibrium, as indicated in the diagram.

The reading on the spring balance attached at the 20 cm mark was 2 N and the reading on the other spring balance was 4 N.

The other end of each spring balance was attached to a fixed support.



1. **Calculate the sum of the upward forces and the sum of the downward forces acting on the metre stick.**

Up = 2 +4 = 6 (N)

Down = 2 +1 +1.8 + 1.2 = 6 (N)

1. **Explain how these experimental values verify one of the laws of equilibrium for a set of co-planar forces.**

The vector sum of the forces in any direction is zero (forces up = forces down).

1. **Calculate the sum of the clockise moments and the sum of the anticlockwise moments about an axis through the 10 cm mark on the metre stick.**

Moment = force × distance

Sum of anticlockwise moments = 2.8 N m

Sum of clockwise moments = 2.8 N m

1. **Explain how these experimental values verify the second law of equilibrium for a set of co-planar forces.**

The sum of the moments about any point is zero.

1. **Describe how the centre of gravity of the metre stick was found.**

Hang the metre stick on a string and adjust the position until the metre stick balances.

Note the position.

1. **Why was it important to have the spring balances hanging vertically?**

Moment of a force = force × perpendicular distance, so if the readings on the metre stick are to correspond to these perpendicular distances then the metre stick must be perpendicular to the spring balances, and if the metre stick is horizontal then the spring balances should be vertical.

2

In an experiment to measure the specific latent heat of fusion of ice, warm water was placed in an

 aluminium calorimeter.

Crushed dried ice was added to the water.

The following results were obtained.

Mass of calorimeter.......................................= 77.2 g

Mass of water.................................................= 92.5 g

Initial temperature of water...........................= 29.4 0C

Temperature of ice ........................................= 0 0C

Mass of ice.....................................................= 19.2 g

Final temperature of water.............................= 13.2 0C

Room temperature was 21 0C.

1. **What was the advantage of having the room temperature approximately halfway between the initial temperature of the water and the final temperature of the water?**

Heat lost to surroundings when the system is above room temperature would cancel out the heat taken in from the surroundings when the system was below room temperature.

1. **Describe how the mass of the ice was found.**

Final mass (of calorimeter + water + ice) - initial mass (of calorimeter + water)

1. **Calculate a value for the specific latent heat of fusion of ice**

*mc*Δθ*Al + mc*Δθ*water* = *mlice +mc*Δθ*melted ice*

Fall in temperature = 16.2 oC

Ans = 3.2 × 105 J kg-1

1. **The accepted value for the specific latent heat of fusion of ice is 3.3 × 105 J kg-1; suggest two reasons why your answer is not this value.**

Thermometer not sensitive enough, lack of insulation, lack of stirring, heat loss/gain to surroundings, too long for ice to melt, inside of calorimeter tarnished, splashing, heat capacity of thermometer

3

A student obtained the following data during an investigation of the variation of the fundamental frequency f of a stretched string with its tension T.

The length of the string was kept constant.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| T/N | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
| f /Hz | 264 | 304 | 342 | 371 | 402 | 431 | 456 |

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

Slowly increase the frequency on the signal generator until resonance occurs.

Note the frequency on the signal generator and the tension on the Newton balance.

Change tension and repeat.

1. **Why was the length of the string kept constant during the investigation?**

Because length is a third variable and you can only investigate the relationship between two variables at a time.

1. **Plot a suitable graph on graph paper to show the relationship between fundamental frequency and tension for the stretched string.**

Square root of tension / frequency squared

Label axes

Plot 6 points correctly

Straight line

Good fit

1. **From your graph, estimate the tension in the string when its fundamental frequency is 380 Hz.**

At a frequency of 380 the square root of tension= 5.6  T = 30.3 N

4

In an experiment to investigate the variation of current I with potential difference V for a copper sulfate solution, the following results were obtained.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V /V | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 |
| I /mA | 24 | 48 | 79 | 102 | 120 | 143 | 185 | 195 | 215 | 263 |

1. **Draw a diagram of the apparatus used in this experiment, identifying the anode and the cathode.**

****Cathode = negative electrode, anode = positive electrode

1. **Draw a suitable graph on graph paper to show how the current varies with the potential difference.**

Axes labelled

6 points plotted correctly

Straight line

Good fit

1. **Using your graph, calculate the resistance of the copper sulfate solution. (Assume the resistance of the electrodes is negligible.)**

Resistance = slope of graph = 19.5 to 20.5 Ohms

1. **Draw a sketch of the graph that would be obtained if inactive electrodes were used in this experiment.**

Straight line starting at v > 0

**2002 Question 5**

1. **A particle travels at a constant speed of 10 m s-1 in a circle of radius 2 m. What is its angular velocity?**

v = rω   ω = 5 rad s-1

1. **Give the equation that defines temperature on the Celsius scale.**

T (0C) = T(K) – 273.15

1. **The solar constant is 1.35 kW m-1.**

**What What is the average amount of energy falling normally on each square metre of the earth’s atmosphere in one year? (one year = 3.16 × 10 7s)**

1350 Joules of energy falls on each m2 in a second.

So in *one year* the number of Joules that falls = (1.35 × 103)(3.16 × 107) = 4.27 ×1010Joules

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

The Doppler effectis the apparent change in the frequency of a wave due to the relative motion between the source of the wave and the observer.

1. **Define sound intensity.**

Sound Intensity is defined as power per unit area.

1. **A diffraction grating has 200 lines per mm.**

**What is the value of d in the diffraction grating formula nλ = d sin θ ?**

 d = 5 × 10-6 m.

1. **How much energy is stored in a 100 μF capacitor if it is charged to a potential difference of 12 V?**

E = ½ CV2 = ½(100 × 10-6)(12)2 = 7.2 × 10-3 J

1. **What is the purpose of a residual current device (RCD) in an electrical circuit?**

It acts as a safety device by breaking the circuit if there is a difference between the live and the neutral in a circuit.

1. **A current-carrying conductor experiences a force when placed in a magnetic field. Name two factors that affect the magnitude of the force.**

Magnetic flux density, current and length.

1. **What is meant by nuclear fission?**

Nuclear fission is the break-up of a large nucleus into two smaller nuclei with the release of energy and neutrons.

**2002 Question 6**

1. **State Newton’s second law of motion.**

Newton’s second law of motion states that *the rate of change* of an object’s momentum is directly proportional to the force which caused it, and takes place in the direction of the force.

1. **Name this law and give a statement of it.**

Hooke’s law states that when an object is stretched (or compressed) the restoring force is directly proportional to the displacement, provided the elastic limit is not exceeded.

1. **Give the name for this type of motion and describe the motion.**

Simple harmonic motion; an object is said to be moving with simple harmonic motion if its acceleration is directly proportional to its distance *from* a fixed point in its path.

1. **Give two other examples of systems that obey this law.**

Stretched elastic, pendulum, oscillating magnet, springs of car, vibrating tuning fork, object bobbing in water waves.

1. **Calculate the value of k, the constant for the springs of the bike.**

Force up = restoring force (which is proportional to *compression*): Fup = –*k*(compression)

Force down = weight = mg Fdown = mg

At equilibrium position, force down = force up

mg = – k(*s*)  (60)(9.8) = *k*(.005)  k = 1.2 × 105 N m-1

1. **Calculate the period of oscillation of the cyclist.**

 ω = 38 s-1 T = 0.16 s

1. **Calculate the number of oscillations of the cyclist per second.**

 *f* = 6.25 Hz Number of full oscillations is 6

**2002 Question** 7

1. **Explain the underlined terms in the above statement.**

*Constructive interference* occurs when waves from two coherent sources meet to produce a wave of greater amplitude.

*Coherent waves*: Two waves are said to be coherent if they have the same frequency and are in phase.

1. **What is the condition necessary for destructive interference to take place when waves from two coherent sources meet?**

They must be out of phase by half a wavelength (this means that the crest of one wave will be over the trough of the other.

1. **Describe an experiment that demonstrates the wave nature of light.**

Shine a laser through a diffraction grating; an interference pattern will be produced on a screen, caused by interference of the light waves

1. **Calculate the wavelength of the radio waves.**

c = fλ  = 10000 m = 10 km

1. **What is the minimum distance that the reflected waves should travel for destructive interference to occur at the receiver?**

For destructive interference to occur the reflected wave must arrive out of phase, i.e. it must have travelled half a wavelength *more* than the regular wave.

The initial wave will have travelled 1500 km and half a wavelength is 5 km (worked out above) therefore the reflected wave must travel 1500 km + 5 km = 1505 km.

1. **Calculate the minimum height of this layer for destructive interference to occur at the receiver.**

Use Pythagoras:

h = 61 km = 61000 m

**2002 Question 8**

1. **Define power.**

Power is the rate at which work is done.

1. **Define resistivity.**

Resistivity is the resistance of a cube of material of side one metre.

1. **Describe an experiment that demonstrates the heating effect of an electric current.**

Connect an electrical calorimeter containing water to a power supply and notice the increase in temperature using a thermometer.

1. **Calculate the total resistance of the cables.**

 A = πr2 = π(0.005)2 = 7.85 × 10-5 m2

  R = 9.6 Ω

1. **Calculate the current flowing in the cables.**

W = VI  = 200 A

1. **Calculate the rate at which energy is “lost” in the cables.**

P = I2R = (200)2(9.6) = 3.8 × 105 W

1. **Suggest a method of reducing the energy “lost” in the cables.**

Higher voltage which would mean lower current / thicker cable for lower resistance

**2002 Question 9**

1. **Explain with the aid of a labelled diagram how X-rays are produced.**
2. Electrons are emitted from the hot cathode due to thermionic emission.
3. They get accelerated across the vacuum due to the very high voltage and smash into the high-density anode (usually tungsten) at B.
4. Some inner electrons in the tungsten get bumped up to a high orbital, then quickly fall back down to a lower lever, emitting X-rays in the process.
5. **Justify the statement “X-ray production may be considered as the inverse of the photoelectric effect.”**

X-ray production: electrons are used to produce electromagnetic radiation

The photoelectric effect: electromagnetic radiation is used to release electrons

1. **Describe an experiment to demonstrate the photoelectric effect.**

Apparatus: gold leaf electroscope with zinc plate on top, ultraviolet light source

Procedure: Charge the electroscope negatively.

 Shine ultraviolet light on the zinc plate.

Observation: The leaves collapse

1. **Outline Einstein’s explanation of the photoelectric effect.**

Electromagnetic radiation consists of packets of energy which he called quanta.

The amount of energy in each quantum could be calculated using the formula *E = hf*

The incoming radiation needs to have sufficient energy to release an electron from the surface of a metal or it won’t be absorbed at all.

If the incoming energy has more energy than an electron needs to be released (called its work function) then the excess energy appears as kinetic energy of the electron.

1. **Give two applications of a photocell.**

Burglar alarm, smoke alarms, safety switch. light meters, automatic lights, counters, automatic doors, control of central heating burners, sound track in films, scanner reading bar codes, stopping conveyer belt

**2002 Question 10 (a)**

1. **Name the four fundamental forces of nature.**

Gravitational, Electromagnetic, Strong nuclear, Weak nuclear

1. **Which force is responsible for binding the nucleus of an atom?**

Strong

1. **Give two properties of this force.**

Short range, act on nucleons, binds nucleus, strongest of all the forces

1. **Outline this experiment.**

Protons are released at the top of the accelerator and get accelerated across a potential difference of 800 kVolt.

These protons collide with a lithium nucleus at the bottom, and as a result two alpha particles are produced.

The alpha particles move off in opposite directions at high speed.

They then collide with a zinc sulphide screen, where they cause a flash and get detected by microscopes.

1. **Write a nuclear equation to represent this reaction.**
2. **Calculate the energy released in this reaction.**

Mass before = [(1.6730 × 10-27) + (1.1646 × 10-26)]

Mass after = [2(6.6443 × 10-27)]

Mass defect = mass before – mass after

Mass defect = 3.0 x 10-29 kg

Using E = mc2  E = (3.0 x 10-29)( 3.00 × 108)2   E = 2.7 × 10-12 J

**2002 Question 11**

Read the following passage and answer the accompanying questions.

Benjamin Franklin designed the lightning conductor. This is a thick copper strip running up the outside of a tall building. The upper end of the strip terminates in one or more sharp spikes above the highest point of the building. The lower end is connected to a metal plate buried in moist earth. The lightning conductor protects a building from being damaged by lightning in a number of ways.

During a thunderstorm, the value of the electric field strength in the air can be very high near a pointed lightning conductor. If the value is high enough, ions, which are drawn towards the conductor, will receive such large accelerations that, by collision with air molecules, they will produce vast additional numbers of ions. Therefore the air is made much more conducting and this facilitates a flow of current between the air and the ground. Thus, charged clouds become neutralised and lightning strikes are prevented. Alternatively, in the event of the cloud suddenly discharging, the lightning strike will be conducted through the copper strip, thus protecting the building from possible catastrophic consequences.

Raised umbrellas and golf clubs are not to be recommended during thunderstorms for obvious reasons.

On high voltage electrical equipment, pointed or roughly-cut surfaces should be avoided.

(Adapted from “Physics – a teacher’s handbook”, Dept. of Education and Science.)

* 1. **Why is a lightning conductor made of copper?**

It is a good conductor.

* 1. **What is meant by electric field strength?**

Electric field strength is defined as force per unit charge. E =

* 1. **Why do the ions near the lightning conductor accelerate?**

They experience a large force due to the high density of charge on the conductor

* 1. **How does the presence of ions in the air cause the air to be more conducting?**

The ions act as charge carriers.

* 1. **How do the charged clouds become neutralised?**

Electrons flow to or from the ground through the air.

* 1. **What are the two ways in which a lightning conductor prevents a building from being damaged by lightning?**

It neutralises charged clouds

It conducts charges to earth.

* 1. **Why are raised umbrellas and golf clubs not recommended during thunderstorms?**

Because they act as lightning conductors.

* 1. **Explain why pointed surfaces should be avoided when using high voltage electrical equipment.**

Sparking is more likely to occur from these points due to point discharge.

**2002 Question 12(a)**

1. **State the principle of conservation of momentum.**

The principle of conservation of momentum states that in any collision between two objects, the total momentum before impact equals total momentum after impact, provided no external forces act on the system.

1. **Calculate the mass of gas that the spacecraft must expel at a speed 50 m s–1 for the spacecraft to lock onto the space station.**Total momentum beforehand = total momentum after

Momentum of spacecraft beforehand = momentum of spacecraft after + momentum of expelled gas

m1u1  = m1v1 + m2v2

(50000 × 2) = (50000 × 0.5) + (*mgas*) (50)

mgas =1500 kg

1. **In what direction should the gas be expelled?**

Forward (toward the space station).

1. **Explain how the principle of conservation of momentum is applied to *changing the direction in which a spacecraft is travelling.***

*{I think this was a trickier question than the examiners realised. As the gas is expelled in one direction the rocket moves in the other direction – but only if the rocket is not moving in that direction initially.*

*If it is moving in the same direction in which the gas is expelled, then expelling the gas will cause the rocketship to decelerate, but not necessarily to change direction.*

*On the other hand if the rocketship expels the gas to the right, then it will accelerate towards the left.}*

**2002 Question 12 (b)**

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

The incident ray, the normal and the refracted ray all lie on the same plane.

The ratio of the sin of the angle of incidence to the sin of the angle of refraction is a constant.

1. **Draw a labelled diagram showing the optical structure of the eye.**

See diagram.

1. **How does the eye bring objects at different distances into focus?**

The shape of the lens can change (by contracting and relaxing the cilary muscles). This causes the focal length (and the power) of the lens to change; this needs to adjust on the basis of whether the person is looking at something up close or something far away.

1. **Calculate the power of the contact lens required to correct the person’s short-sightedness.**

PTotal = P1 + P2 P*corrected eye* = P*defective eye* + P*corrective lens*

60 = 65+ P2

P2 = - 5 m *{the negative sign indicates that it is a concave or diverging lens}*

1. **Calculate the focal length of the contact lens required to correct the person’s short-sightedness.**

  f = 0.2 m

*{notice that the negative sign has no mathematical significance and so can be ignored here}*

**2002 Question 12 (c)**

1. **What is meant by electromagnetic induction?**

Electromagnetic Induction occurs when an emf is induced in a coil due to a changing magnetic flux.

1. **State Lenz’s law of electromagnetic induction.**

Lenz’s Law states that the direction of the induced emf is always such as to oppose the change producing it.

1. **Explain why the current was reduced when an iron core was inserted in the coil.**

There would normally be a back emf in the coil due to the fact that source voltage is alternating.

When the core was inserted it increased the magnetic flux which in turn increased the self-induction (back emf) and this reduced the overall voltage and therefore the overall current.

1. **Give an application of the principle shown by this experiment.**

Dimmer switch

**2002 Question 12 (d)**

1. **Name the scientist who carried out this experiment.**

Ernest Rutherford.

1. **Describe what was observed in this experiment.**

Most alpha particles passed straight through, some were deflected slightly and a small percentage bounced back.

1. **Why was it necessary to carry out this experiment in a vacuum?**

To prevent the alpha particles colliding with other particles.

1. **What conclusion did the scientist form about the structure of the atom?**

It consists of a small, dense, positively charged core with negatively charged electrons in orbit around it.