Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2014

Marking Scheme

Physics

Higher Level

Note to teachers and students on the use of published marking schemes

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates' work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates' work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates' work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.

General Guidelines

In considering this marking scheme the following points should be noted.

1. In many instances only key words are given – words that must appear in the correct context in the candidate's answer in order to merit the assigned marks.

2. Words, expressions or statements separated by a solidus, /, are alternatives which are equally acceptable. Words which are separated by a solidus and which are underlined, must appear in the correct context by including the rest of the statement to merit the assigned mark.

3. Answers that are separated by a double solidus, //, are answers which are mutually exclusive. A partial answer from one side of the // may not be taken in conjunction with a partial answer from the other side.

4. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.

5. The detail required in any answer is determined by the context and manner in which the question is asked and also by the number of marks assigned to the answer in the examination paper. Therefore, in any instance, it may vary from year to year.

6. For omission of appropriate units, or incorrect units, one mark is deducted, when indicated.

7. Each time an arithmetical slip occurs in a calculation, one mark is deducted.

1. The following is part of a student's report on an experiment to verify the principle of conservation of momentum.

> "I ensured that no net external forces acted on body A or body B. When I released body A it was moving at a constant velocity; body B was at rest. I allowed body A to collide with body B and they moved off together after the collision."

The following data was recorded:

Mass of body A	= 325.1 g
Mass of body B	= 349.8 g
Velocity of body A before the collision	= 0.84 m s^{-1}
Velocity of bodies A and B after the collision	= 0.41 m s^{-1}

Draw a labelled diagram of the apparatus used in the experiment.

State what measurements the student took and how these measurements were used to calculate the velocities.

diagram:	**two bodies and track**	**(3)**
	labelled means of attaching the two bodies	**(3)**
	timer / motion sensor	**(3)**
measurements:	**masses**	**(3)**
	time for n gaps // time for body to pass through light gate // approp. time	**(3)**
	length of n gaps // length of (card)body // approp. distance	**(3)**
calculate:	**distance ÷ time // appropriate slope = velocity**	**(3)**

Using the recorded data, show how the experiment verifies the principle of conservation of momentum.

$0.3251 \times 0.84 = 0.273$ kg m s^{-1} **(3)**

$(0.3251 + 0.3498) \times 0.41 = 0.277$ kg m s^{-1} **(3)**

0.273 kg m s^{-1} $\approx$ 0.277 kg m s^{-1}/ or equivalent **(3)**

(3 marks for formula only)

(–1 for omission of or incorrect units)

When carrying out this experiment the student ensures that there is no net external force acting on the bodies.

What are the two forces that the student needs to take account of to ensure this?

Describe how the student reduced the effects of these forces.

weight (gravitational force) **(4)**

friction **(4)**

horizontal (air)track / cushion of air / (small) slope / polish runway / oil wheels **(2)**

2. In an experiment to measure the refractive index of a substance, a student used a rectangular block of the substance to measure the angle of incidence *i* and the corresponding angle of refraction *r* for a ray of light as it passed from air into the substance. The student repeated the procedure for a series of different values of the angle of incidence and recorded the following data.

i (degrees)	20	30	40	50	60	70	80
r (degrees)	13	20	27	23	36	40	43

One of the recorded angles of refraction is inconsistent with the others. Which one?

23 ° **(4)**

Describe, with the aid of a labelled diagram, how the student found the angle of refraction.

rectangular block

pins / ray box / laser *(–1 if no label)*

correct incident, normal and refracted rays drawn

angle of refraction indicated

protractor / trigonometry *(any four)* **(4 × 3)**

Calculate a value for the refractive index of the substance by drawing a suitable graph based on the recorded data.

Sin i	**0.34**	**0.50**	**0.64**	**0.77**	**0.87**	**0.94**	**0.98**
Sin r	**0.23**	**0.34**	**0.45**	**0.39**	**0.59**	**0.64**	**0.68**

sin *i* and sin *r* calculated *(–1 for each incorrect value)* **(3)**
axes labelled **(3)**
6 points plotted *(–1 for each incorrect point)* **(3)**
straight line with good fit **(3)**
method for finding slope **(3)**
slope = n ≈ 1.44 **(3)**
(–1 for inappropriate scale)

Using a graph to calculate a value for the refractive index is a more accurate method than calculating the refractive index for each pair of angles and then finding the mean.
Give two reasons for this.

outliers can be identified / slope gives weighted mean / reference to origin

/ reference to Tan θ *(any two)* **(4 + 2)**

3. A student used a cylindrical column of air closed at one end and a tuning fork of frequency 512 Hz in an experiment to measure the speed of sound in air.

The following data was recorded:

Length of column of air for first position of resonance = 16.2 cm
Diameter of air column = 1.15 cm

Draw a labelled diagram of the apparatus used in the experiment.

(vibrating) tuning fork **(3)**

column of air **(3)**

means of changing length of column / metre stick and callipers **(3)**

(–1 if no label)

Describe how the first position of resonance was found.

hold (vibrating) fork over column **(3)**

increase length of column (from zero) *(accept "change length of column")* **(3)**

until (loudest) sound is heard (from column) **(3)**

Using the recorded data, calculate the speed of sound in air.

$v = 4f(l + 0.3d)$ **(3)**

$v = 4f(0.16545)$ **(3)**

$v = 338.8 \text{ m s}^{-1}$ *(–1 for omission of or incorrect units)* **(3)**

Why was it necessary to measure the diameter of the air column?

because wave exists partially above the top of the tube **(6)**

(accept "end correction", "error in length" etc. for 3 marks)

Another student carried out the experiment by measuring the length of the column of air for each of the first two positions of resonance but did not measure the diameter of the air column.
Explain how this second student would find the speed of sound in air.

find distance between first two positions of resonance / $l_2 – l_1$ **(3)**

double this distance for wavelength / $\lambda = 2(l_2-l_1)$ **(2)**

multiply wavelength by frequency (for speed) / (v =) $f\lambda$ **(2)**

4. In an experiment to verify Joule's law, a fixed mass of water was heated in an insulated cup. θ, the highest temperature reached, was recorded for different values of current, I. In each case the current flowed for 4 minutes and the initial temperature of the water was 20.0 °C. The recorded data is shown in the table.

I (A)	1.0	1.5	2.0	2.5	3.0	3.5
θ (°C)	22.0	24.5	28.5	34.0	38.5	45.5

Draw a labelled diagram of the apparatus used in the experiment.

coil in water **(3)**

power supply *or* battery with variable resistor, ammeter **(3)**

thermometer **(3)**

correct circuit diagram *(–1 if no label)* **(3)**

Draw a suitable graph to verify Joule's law. Explain how the graph verifies Joule's law.

I^2/A^2	**1**	**2.25**	**4**	**6.25**	**9**	**12.25**
$\Delta\theta/K$	**2.0**	**4.5**	**8.5**	**14.0**	**18.5**	**25.5**

Draw: **six I^2 values calculated** *(–1 each incorrect/missing value)* **(3)**

axes labelled **(3)**

6 points plotted *(–1 each incorrect point)* **(3)**

straight line with good fit **(3)**

(–1 for inappropriate scale)

Explain: **straight line through origin / I^2 proportional to rise in temperature / P proportional to I^2** **(6)**

Use your graph to estimate the highest temperature of the water if a current of 1.6 A flows through the coil for 4 minutes.

I^2 = 2.56 **(3)**

highest temperature ≈ 25.3 °C *(–1 for failure to add 20)* **(3)**

(–1 for omission of or incorrect units)

Explain why a fixed mass of water was used.

(power required for) temperature rise is proportional to mass / otherwise there would be too many variables **(4)**

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

(*a*) State Boyle's law.
p and V inversely proportional **(4)**
for a fixed mass of gas at constant temperature **(3)**

(*b*) The Martian moon Phobos travels in a circular orbit of radius 9.4×10^6 m around Mars with a period of 7.6 hours. Calculate the mass of Mars.
$\mathbf{T^2 = 4\pi^2R^3/GM}$ **(4)**
$\mathbf{6.57 \times 10^{23}}$ **kg** *(–1 for omission of or incorrect units)* **(3)**

(*c*) On what thermometric properties are (*i*) the thermocouple and (*ii*) the mercury-in-glass thermometers based?
(i) emf; (ii) length/height/volume **(4 + 3)**

(*d*) The *U*-value of the material in a double-glazed window in a house is 2.8 W m^{-2} K^{-1}. The window has an area of 3.0 m^2. How much energy is lost through the window in one hour if the temperature inside the house is 20 °C and the outside temperature is 11 °C?
272160 J *(–1 for omission of or incorrect units)* **(7)**
(4 marks for $\Delta E/\Delta t = AU\Delta\theta$)
(3 marks for 9 °C or 3600 s)

(*e*) List a pair of complementary colours of light.
any one primary colour **(2)**
any one secondary colour **(2)**
correct pair: red and cyan / green and magenta / blue and yellow **(3)**

(*f*) What are the charge carriers in (*i*) semiconductors and (*ii*) metals?
(i) electrons and holes; (ii) electrons **(2 × 2; 3)**

(*g*) With reference to domestic electric circuits, what do the letters in the acronyms RCD and MCB stand for?
residual current device; miniature circuit breaker **(6 × 1 + 1)**

(*h*) The work function of tungsten is 4.50 eV. Calculate the maximum kinetic energy of an electron ejected from a tungsten surface when electromagnetic radiation whose photon energy is 5.85 eV shines on the surface.
Energy of incident photon = Work function + KE of electron **(4)**
1.35 (eV) / $\mathbf{2.16 \times 10^{-19}}$ **(J)** **(3)**

(*i*) Describe Rutherford's model of the atom.
mostly empty space / dense core / positive core / electron cloud *(any two)* **(4 + 3)**

(*j*) ETS Walton is Ireland's only Nobel Prize winner in the sciences. Give two reasons why the Cockcroft and Walton experiment was significant to the understanding of particle physics.
first experimental verification of $\mathbf{E = mc^2}$ **/ first transmutation using artificially accelerated particles / first artificial splitting of a nucleus / development of linear accelerator** *(any two)* **(4 + 3)**

Describe how a galvanometer may be converted into a voltmeter.
connect a large resistor / multiplier **(4)**
in series **(3)**

6. Compare vector and scalar quantities.
Give one example of each.

vectors have direction **(2)**
scalars have no direction **(2)**
e.g. velocity and speed **(2 × 2)**

Describe an experiment to find the resultant of two vectors.

apparatus and arrangement e.g. 3 weights and pulleys **(3)**
procedure and measurements e.g. adjust and read each force **(3)**
observation and result e.g. statement *(–1 if correct direction not shown)* **(3)**

A golfer pulls his trolley and bag along a level path. He applies a force of 277 N at an angle of 24.53° to the horizontal. The weight of the trolley and bag together is 115 N and the force of friction is 252 N.

Calculate the net force acting on the trolley and bag.

Horizontal force applied by golfer = 277Cos24.53° ≈ 252 N **(3)**
Vertical force applied by golfer = 277Sin24.53° ≈ 115 N **(3)**
Net force ≈ 0 N **(3)**

What does the net force tell you about the golfer's motion?

constant speed **(3)**

Use Newton's second law of motion to derive an equation relating force, mass and acceleration.

F proportional to (mv – mu)/t **(2)**
F proportional to ma **(2)**
F = kma **(2)**
k = 1 (by definition of the newton) **(2)**
F = ma **(1)**

A force of 5.3 kN is applied to a golf ball by a club. The mass of the ball is 45 g and the ball and club are in contact for 0.54 ms.

Calculate the speed of the ball as it leaves the club.

F = ma // I = Ft // F = (mv – mu)/t **(3)**
correct substitution **(3)**
v = 63.6 m s^{-1} *(–1 for omission of or incorrect units)* **(3)**

The ball leaves the club head at an angle of 15° to the horizontal. Calculate the maximum height reached by the ball. You may ignore the effect of air resistance.

u_y = 16.46 m s^{-1} **(3)**
$v^2 = u^2 + 2as$ // $½mv^2 = mgh$ **(3)**
height = 13.82 m *(–1 for omission of or incorrect units)* **(3)**

7. What is meant by the terms (*i*) diffraction and (*ii*) interference?

(i) **the spreading of a wave** **(3)**

into the space beyond a barrier/obstacle/gap **(3)**

(ii) **the addition/(meeting) of two or more waves (to form a new wave)** **(3)**

A laser produces a beam of red light with a wavelength of 709 nm. The beam is incident on a diffraction grating, as shown in the diagram. A diffraction pattern is formed on a screen. A second order image is detected at an angle of 34.6° from the central image.

Calculate the energy of each photon in the laser beam.

E = hf **(3)**

c = fλ **(3)**

E = 2.8 × 10^{-19} J *(–1 for omission of or incorrect units)* **(3)**

Sensors in the eye can respond to single photons. Where in the eye are these sensors located?

retina **(3)**

State two differences between the electromagnetic radiation emitted from a laser and the electromagnetic radiation emitted from a vapour lamp.

laser has one frequency/wavelength only / laser light is more powerful / laser light is coherent / laser light is collimated *(any two)* **(4 + 2)**

Derive, with the aid of a labelled diagram, the diffraction grating formula.

diffraction grating, two rays on diagram **(3)**

θ and d indicated on diagram **(3)**

nλ indicated on diagram *(if n =1 award zero marks)* **(3)**

nλ linked to constructive interference **(3)**

Sinθ = nλ/d from diagram **(3)**

Calculate the number of lines per millimetre on the grating used in the experiment.

nλ = dSinθ **(3)**

d = 0.000002497 m **(3)**

i.e. 400 (lines per mm) **(3)**

What would be observed on the screen if the laser was replaced by a source of white light?

spectra / dispersion / colours **(5)**

8. A nuclear reactor is a device in which a sustained chain reaction takes place. From each nuclear fission reaction, only one (on average) of the emitted neutrons hits another nucleus to cause another fission. The power output from a sustained nuclear reaction doesn't grow, but is constant.

Explain the underlined terms.

a self-sustaining reaction / a reaction where the release of one or more neutrons causes further fission **(3)**
fission is the splitting of a large nucleus **(3)**
into two (smaller) nuclei with the release of energy/neutrons *(−1 if atom used)* **(3)**

A substance called a moderator is mixed with the fuel in a nuclear reactor. Control rods are used to control the rate of the reaction.

Give an example of a moderator.

graphite / (heavy) water **(3)**

Explain (*i*) why a moderator is needed in a nuclear reactor and (*ii*) how the control rods affect the rate of the reaction.

(i) to slow down neutrons / so as to increase the probability of fission **(6)**
(ii) by absorbing neutrons **(6)**

A heat exchanger is used in a nuclear reactor.

Explain how the heat exchanger operates. Why is it necessary to use a heat exchanger?

heat/energy from reactor **(3)**
transfers to liquid/water in heat exchanger (to drive a turbine) **(3)**
the material in a reactor is radioactive / allows the core to reach a higher temperature **(4)**

Plutonium is produced in a fission reactor when one of the neutrons released in the fission reaction converts uranium–238 into plutonium–239 with the emission of two beta-particles.

Write an equation for this nuclear reaction.

$${}^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{239}_{94}Pu + 2\,{}^{0}_{-1}\beta$$

(–3 for extra particles) **(10 × 1)**

Each fission of a uranium–235 nucleus produces 202 MeV of energy. Only 35% of this energy is used to generate electricity. How many uranium–235 nuclei are required to undergo fission to generate a constant electric power of 1 GW for a day?

Each fission = $(202 \times 10^6)(1.6 \times 10^{-19})$ / 3.23×10^{-11} J **(3)**
35% of 202 MeV = 1.13×10^{-11} J **(3)**
1 GW for a day = 8.64×10^{13} J **(3)**
7.65×10^{24} nuclei **(3)**

9. Most modern electronic devices contain a touchscreen. One type of touchscreen is a capacitive touchscreen, in which the user's finger acts as a plate of a capacitor. Placing your finger on the screen will alter the capacitance and the electric field at that point.

Explain the underlined terms.

capacitance is the ratio of charge (on a capacitor) **// C = Q/V** **(3)**
to the potential difference (across it) **// correct notation** **(3)**
an electric field is a region (of space) **(3)**
where electrostatic forces are experienced / forces experienced by charged particles **(3)**

Describe an experiment to demonstrate an electric field pattern.

high voltage **(3)**
connected to two plates **(3)**
in oil and semolina **(3)**
semolina forms electric field pattern **(3)**

Two parallel metal plates are placed a distance *d* apart in air. The plates form a parallel plate capacitor with a capacitance of 12 μF. A 6 V battery is connected across the plates.

Calculate (*i*) the charge on each plate and (*ii*) the energy stored in the capacitor.

(i) **C = Q/V** **(3)**
Q = 72 μC *(–1 for omission of or incorrect units)* **(3)**
(ii) **E = ½CV^2** **(3)**
E = 216 μJ *(–1 for omission of or incorrect units)* **(3)**

While the battery is connected the distance *d* is increased by a factor of three. Calculate the new capacitance.

(iii) **4 (μF)** **(4)**

A capacitor and a battery are both sources of electrical energy. State two differences between a capacitor and a battery.

capacitor discharges faster than a battery / capacitor stores (electrostatic) potential energy while a battery stores chemical energy / battery gives a constant current / battery stores more energy *(any two)* **(4 + 2)**

Touchscreens also contain two polarising filters. What is meant by polarisation of light?

vibration (of a wave) **(3)**
is in one plane **(3)**

Give one application of capacitors, other than in touchscreens.

e.g. flash of a camera / tuning circuits / defibrillator **(4)**

10. Blood pressure can be measured in many ways. One technique uses the Doppler effect; another uses strain gauges contained in Wheatstone bridges.

What is the Doppler effect?
the (apparent) change in the frequency (of a wave) **(3)**
due to the relative motion between the source (of the wave) and the observer **(3)**

Explain, with the aid of labelled diagrams, how the Doppler effect occurs.
source, concentric circles labelled as waves **(3)**
source moving towards/away from observer, non-concentric circles **(3)**
wavelength shorter moving towards the observer (or equivalent) **(3)**
therefore frequency greater (or equivalent) **(3)**

An ambulance siren emits a sound of frequency 750 Hz. When the ambulance is travelling towards an observer, the frequency detected by the observer is 820 Hz.

What is the speed of the ambulance?
Doppler formula **(3)**
correct substitution **(3)**
correct rearrangement for u **(3)**
29 m s^{-1} *(–1 for omission of or incorrect units)* **(3)**

State two other practical applications of the Doppler effect.
e.g. police "speed guns" / measuring velocities of stars / ultrasound (scan) /
landing aircraft / weather forecasting *(any two)* **(2 × 2)**

The resistance of the conductor in a strain gauge increases when a force is applied to it. Strain gauges can act as the resistors in a Wheatstone bridge, and any change in their resistance can then be detected.

How would an observer know that a Wheatstone bridge is balanced?
zero reading on / no deflection of / no current flowing through **(2)**
galvanometer **(2)**

The Wheatstone bridge in the diagram is balanced.

What is the resistance of the unknown resistor?
$R_1 \div R_2 = R_3 \div R_4$ **(3)**
17.36 Ω *(–1 for omission of or incorrect units)* **(3)**

Write an expression for the resistance of a wire in terms of its resistivity, length and diameter.
$R = \rho l/A$ **(3)**
$R = 4\rho l/\pi d^2$ **(3)**

The radius of a wire is doubled. What is the effect of this on the resistance of the wire?
resistance decreases **(3)**
by a factor of 4 **(3)**

11. (*a*)

(*i*) Electrons are leptons. List the three fundamental forces that electrons experience in increasing order of strength.

gravitational, weak (nuclear) and electromagnetic **(3 × 2)**
in correct order **(1)**

(*ii*) Write an equation to represent the pair annihilation described in the text.

$e^- + e^+$ **// $2m_ec^2$** **(4)**
$\rightarrow 2hf / 2\gamma$ **// = 2hf** **(3)**

(*iii*) Calculate the frequency of each photon produced in this pair annihilation.

$hf = mc^2$ **(4)**
1.2356×10^{20} Hz *(–1 for omission of or incorrect units)* **(3)**

(*iv*) Why do the photons in pair annihilation travel in opposite directions?

momentum **(4)**
is conserved **(3)**

(*v*) Write a nuclear equation to represent the decay of carbon–11.

$^{11}_{6}C \rightarrow {}^{11}_{5}B + {}^{0}_{1}e \ (+\nu_e)$ *(–3 for extra particles)* **(7 × 1)**

(*vi*) What is the decay constant of carbon–11?

$\lambda = \ln 2/T_{½}$ **(4)**
$0.000578\ s^{-1}$ *(–1 for omission of or incorrect units)* **(3)**

(*vii*) Explain why the carbon–11 nuclei used in the PET scanner must be produced in a cyclotron in, or close to, the same hospital as the scanner.

short half-life / too many would have decayed before they could be used **(7)**

(*viii*) Give an expression for the momentum of a particle in the cyclotron in terms of the magnetic flux density of the field, the charge on the particle and the radius of its circular path at any instant.

qrB *(centripetal force = magnetic force for 4 marks)* **(7)**
(qvB or mv^2/r or $mr\omega^2$ for 4 marks)
(–1 if "e" is used in place of "q")

(*b*)

(*i*) Draw a labelled diagram to show the basic structure of a transistor.

npn / pnp layers **(4)**
collector, base and emitter all shown correctly **(3)**

(*ii*) State the relationship between the three currents flowing in a transistor.

$\mathbf{I_e = I_b + I_c}$ **(7)**

(*iii*) Draw a circuit diagram for a voltage amplifier.

transistor and resistor in series **(4)**
complete circuit with input and output voltages indicated **(3)**

(*iv*) Draw the symbol and truth table for an AND gate.

correct symbol **(4)**
correct table **(3)**

(*v*) Give two ways in which the operation of a photodiode differs from that of an LED.

photodiode requires light to allow current to flow, LED produces light when a current flows / photodiode is in reverse bias, LED is in forward bias / photodiode does not need a protective resistor, LED does *(any two)* **(4 + 3)**

(*vi*) What event inside an LED causes the release of a photon?

electron drops to a lower energy level (combines with a hole) **(7)**

(*vii*) Explain, with the aid of a labelled diagram, how a ray of light is guided along an optical fibre.

angle of incidence greater than critical angle / total internal reflection **(4)**
more than once on diagram **(3)**

(*viii*) Give an expression for the critical angle of the glass in an optical fibre in terms of the speed of light in the glass and the speed of light in air.

$\mathbf{Sin\ C = c_{glass}/c_{air}}$ **(4)**
$\mathbf{C = Sin^{-1}(c_{glass}/c_{air})}$ **(3)**

12. Answer any **two** of the following parts (*a*), (*b*), (*c*), (*d*).

(*a*) State Hooke's law.

extension proportional to	**// (restoring) force prop. to**	**// F = (−)ks**	**(2)**
(applied)force	**// displacement**	**// notation**	**(2)**

The elastic constant of a spring is 12 N m^{-1} and it has a length of 25 mm. An object of mass 20 g is attached to the spring.

What is the new length of the spring?

x = F/k = (0.02 × 9.8)/12 = 0.0163 m **(3)**

new length = 41.3 mm *(–1 for omission of or incorrect units)* **(3)**

The object is then pulled down until the spring's length is increased by a further 5 mm and is then released. The object oscillates with simple harmonic motion.

Sketch a velocity-time graph of the motion of the object.

axes labelled **(3)**
periodic graph **(3)**
correct sinusoidal shape, beginning with v = 0 **(3)**

Calculate the period of oscillation of the object.

ω^2 = k/m (= 600) **(3)**
T = 2π/ω **(3)**
T = 0.256 s *(–1 for omission of or incorrect units)* **(3)**

(*b*) What is reflection?

light rebounding (off surfaces) **(3)**

Spherical mirrors can be either convex or concave.

Draw a ray diagram to show the formation of an image in a convex mirror.

object, correct mirror **(3)**
two correct reflected rays **(3)**
correct image **(3)**

A person looks at her image in a shiny spherical decoration when her face is 30 cm from the surface of the decoration. The diameter of the decoration is 20 cm. Find the position of the image.

f = r/2 = 5 cm *(–1 if f = 10 cm used)* **(3)**
1/u + 1/v = 1/f **(3)**
substitution **(3)**
v = 30/7 = 4.3 cm (behind the mirror) **(3)**
(–1 for omission of or incorrect units)

Concave mirrors, rather than convex mirrors, are used by dentists to examine teeth. Explain why.

to give a magnified image **(4)**

(*c*) Define specific latent heat.

heat needed to change the state **(3)**
of 1 kg of a substance (with no change in temperature) **(3)**

A drinking glass contains 500 g of water at a temperature of 24 °C. Three cubes of ice, of side 2.5 cm, are removed from a freezer and placed in the water. The temperature of the ice is –20 °C.

Calculate the mass of the ice.
m = ρV **(3)**
m = 43.125 g *(–1 for omission of or incorrect units)* **(3)**
(–1 if one lump of ice used)

Calculate the minimum temperature of the water when the ice has melted.

any mcΔθ *(stated or implied)* **(3)**
ml *(stated or implied)* **(3)**

$$m_{ice}c_{ice}\Delta\theta_1 + m_{ice}l_{ice} + m_{ice}c_{water}\Delta\theta_2 = m_{water}c_{water}\Delta\theta_3$$

$$(0.043125\times2100\times20) + (0.043125\times3.3\times10^5) + (0.043125\times4200\times T) = (0.5\times4200\times(24-T))$$

(4 × 2)

$$1811.25 + 14231.25 + 181.125T = 50400 - 2100T$$

$$2281.125T = 34357.5$$

T = 15.06 °C *(–1 for omission of or incorrect units)* **(2)**

density of ice	$= 0.92\ g\ cm^{-3}$
specific heat capacity of water	$= 4200\ J\ kg^{-1}\ K^{-1}$
specific heat capacity of ice	$= 2100\ J\ kg^{-1}\ K^{-1}$
specific latent heat of fusion of ice	$= 3.3 \times 10^5\ J\ kg^{-1}$

(*d*) State Faraday's law of electromagnetic induction.

(size of an) induced emf is proportional to **(3)**
the rate of change of flux (through a circuit) **(3)**

Describe an experiment to demonstrate Faraday's law.

coil, meter, magnet **(3)**
reading on meter when coil is moved relative to magnet **(3)**
faster movement gives larger reading **(3)**

A hollow copper pipe and a hollow glass pipe, with identical dimensions, were arranged as shown in the diagram. A student measured the time it took a strong cylindrical magnet to fall through each cylinder. It took much longer for the magnet to fall through the copper pipe. Explain why.

(falling) magnet creates changing magnetic flux/field **(3)**
emf induced **(3)**
current flows in copper (only) **(4)**
generating magnetic fields which oppose the motion (of the falling magnet) **(3)**

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