Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2004

PHYSICS – HIGHER LEVEL

MARKING SCHEME

Section A (120 marks)

Each question carries 40 marks. Marks awarded for the **three** best answers.

Question 1

In an experiment to measure the acceleration due to gravity *g* by a free fall method, a student measured the time *t* for an object to fall from rest through a distance *s*. This procedure was repeated for a series of values of the distance *s*.

Describe, with the aid of a diagram, how the student obtained the data. (12)

diagram: timer, sphere, solenoid /two (shorted) contacts 3
release mechanism / (*Start-Stop*) switch reference; pressure plate/trap door 3
'clock starts as sphere is released' stated or implied 3
record distance *s* and the time *t* 3

(No diagram: max. 3 × 3)

For ticker timer method, (max. 3 × 3)
diagram: timer, sphere, tape (3)
start timer and drop sphere (3)
count dots (to find time) (3)

Calculate a value for *g* by drawing a suitable graph. (21)

s/cm	30	40	50	60	70	80	90
t/ms	244	291	325	342	371	409	420
t^2 /s^2	0.060	0.085	0.106	0.117	0.138	0.167	0.176

calculation of t^2 (at least five correct values) 3
axes s and t^2 labelled 3
at least five points correctly plotted 3
straight line with good fit 3
method for slope (e.g. $m = \frac{y_2 - y_1}{x_2 - x_1}$ / tan θ / $\frac{\Delta y}{\Delta x}$) 3
correct substitution 3
$g = 10.0 \pm 0.2$ ms^{-2} 3

(-1 for omission of or incorrect units.)

Give two precautions that should be taken to ensure a more accurate result. (7)

measure from bottom of sphere; avoid parallax error;
for each value of *s* take several values for *t*; t_{min} reference;
ensure no external force (e.g. draughts, etc.) acts on sphere (during release);
adjust 'sensitivity' of trap door; adjust 'sensitivity' of electromagnet (using paper between sphere and core); adjust position of iron core;
use large values for *s* (to reduce % error); use millisecond timer.

any *two* points 4+3

Question 2

In an experiment to measure the wavelength of monochromatic light, the angle θ between a central bright image (n = 0) and the first and second order images to the left and the right was measured. A diffraction grating with 500 lines per mm was used.

n	2	1	0	1	2
θ/ degrees	36.2	17.1	0	17.2	36.3

Describe, with the aid of a diagram, how the student obtained the data. (12)

monochromatic light source/sodium, grating, spectrometer 3
arrangement 3
note readings (on scale) for n = 1,2 on one side of zero order 3
note readings for n = 1,2 on other side of zero order 3
(-1 if no reference to turntable/scale)

For laser method:
laser/ monochromatic source, grating, metre rule (3)
arrangement (3)
measure distance x from central fringe for $n = \pm1, \pm2$ // draw lines (3)
measure distance D from grating to screen and calculate θ in each case // measure θ (3)
(-1 if no reference to method of obtaining θ)

Use all of the data to calculate a value for the wavelength of the light. (15)

$n\lambda = d\sin\theta$ 3

$d = \frac{1}{5\times10^5}$ or $d = 2 \times 10^{-6}$ 3

for n = 1, $\theta_{ave} = 17.15^o \Rightarrow \lambda = 589.7$ nm // n=1, λ_L= 588.1 nm, λ_R= 591.4 nm 3

for n= 2, $\theta_{ave} = 36.25^o \Rightarrow \lambda = 591.3$ nm // n=2, λ_L= 590.6 nm, λ_R= 592.0 nm 3

Calculated average wavelength = 590 ± 1 nm 3
(-1 for omission of or incorrect units)

Explain how using a diffraction grating with 100 lines per mm leads to a less accurate result. (7)

values for θ / $sin\theta$ would be smaller / smaller separation 4
greater percentage error 3

The values for the angles on the left of the central image are smaller than the corresponding ones on the right. Suggest a possible reason for this. (6)

grating may not be perpendicular to incident light
zero error (on scale for n = 0) any one 6

Question 3

A student investigated the variation of the fundamental frequency *f* of a stretched string with its length *l*.
Draw a labelled diagram of the apparatus used in this experiment. Indicate on the diagram the points between which the length of the wire was measured. (12)

<u>diagram:</u> stretched wire, bridges // string, slit / bridge 3
tuning fork / frequency generator + magnet // frequency generator +vibrator 3
length indicated as distance between: bridges // slit/bridge and vibrator 6
(at least one label required, otherwise -1)

The student drew a graph, as shown, using the data recorded in the experiment, to illustrate the relationship between the fundamental frequency of the string and its length.
State the relationship and explain how the graph verifies it. (9)

$f \propto \frac{1}{l}$ / $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ 3
straight line 3
through origin 3

The student then investigated the variation of the fundamental frequency *f* with tension *T*.
The length was kept constant throughout this investigation.
How was the tension measured? (4)

newton balance / pan with weights / newtonmeter /suspended weights 4

What relationship did the student discover? (6)

$f \propto$ 3
$\sqrt{T}$ 3
(graph showing correct straight line with labelled axes .. 2 × 3)

Why was it necessary to keep the length constant? (3)

f depends on length / $f \propto \frac{1}{l}$ / cannot proceed with three variables 3

How did the student know that the string was vibrating at its fundamental frequency? (6)

paper rider on string // nodes // node // antinode 3
falls off // at bridges // at slit or bridge // at centre 3
(correct diagram merits 2 × 3)

Question 4

The following is part of a student's report of an experiment to measure the resistivity of nichrome wire. 'The resistance and length of the nichrome wire were found. The diameter of the wire was then measured at several points along its length.' The following data was recorded.

resistance of wire = 32.1 Ω
length of wire =90.1 cm
diameter of wire = 0.19 mm, 0.21 mm, 0.20 mm, 0.21 mm, 0.20 mm

Name an instrument to measure the diameter of the wire and describe how it is used. (12)

micrometer (screw gauge) / **digital** Vernier callipers 3
place wire between jaws 3
close / tighten jaws 3
read the (two) scale(s) 3
(If "digital" omitted for Vernier callipers … -1)

Why was the diameter of the wire measured at several points along its length? (6)

to determine the average diameter 3
as wire (diameter) may be non-uniform 3

Using the data, calculate a value for the resistivity of nichrome. (15)

average diameter = 0.20(2) (mm) 3
$A = \pi r^2$ / 3.2×10^{-8} (m^2) / 3.20×10^{-2} (mm^2) / 3.14×10^{-8} (m^2) 3

$\rho = \dfrac{RA}{l}$ 3

$\rho = \dfrac{(32.1)(3.2\times10^{-8})}{0.901}$ **(-1 for inconsistent use of units here)** 3

$\rho = 1.1\times10^{-6}\ \Omega\text{ m}$ 3
(-1 for omission of or incorrect unit)

Give two precautions that should be taken when measuring the length of the wire. (7)

ensure wire is taut
no kinks in wire
only measure length whose *R* value was measured
wire at constant temperature
avoid parallax error, etc.

any two 4 + 3

Section B (280 marks)

Each question carries 56 marks. Marks awarded for the best **five** answers.

Question 5

Marks awarded for the *eight* best answers.

(a) Two forces are applied to a body, as shown. What is the magnitude of the resultant force acting on the body? (7)

$R^2 = F_1^2 + F_2^2$ / $R^2 = 5^2 + 12^2$ 4

$R = 13$ (N) 3

(b) A can of height 10 cm is submerged in water. What is the difference in pressure between the top and the bottom of the can? (7)

$P = \rho gh$ / $P = (1000)(9.8)(0.1)$ 4

P =980 Pa / N m^{-2} **(-1 for omission of or incorrect units)** 3

(c) Explain the term thermometric property. (7)

a (physical) property that changes measurably/continuously/uniformly, etc. 4

with temperature 3

(d) The sound intensity doubles as a person approaches a loudspeaker. What is the increase in the sound intensity level? (7)

{ reference to $\log\left(\frac{I}{I_0}\right)$ / log 2 or similar 4}

3 dB **(-1 for omission of or incorrect units)** 7

(e) Two converging lenses, each with a focal length of 10 cm, are placed in contact. What is the power of the lens combination? (7)

$P = \frac{1}{f}$ / = 10 m^{-1} (accept "dioptre") 4

$P = P_1 + P_2$ / = 20 m^{-1} **(-1 if no clear indication that m^{-1} is the unit)** 3

(f) What is meant by polarisation of waves? (7)

vibrations (confined to) 4

one plane (only) 3

(diagram showing polarised and unpolarised concept ... 7)

(g) Identify two hazards caused by static electricity. (7)

electric shock / explosion in flour mills /explosion when fuelling aircraft / damage to electronic devices / electrical storm / static cling / point discharge

any two 4+3

(h) The activity of a radioactive isotope decays to $\frac{1}{16}^{th}$ of its original value after 36 years. What is the half-life of the isotope? (7)

9 years (any reference to <u>four</u> half-lives / $4T_{\frac{1}{2}}$ …4 marks) 7

(i) Give one use of the earth's magnetic field. (7)

compass / navigation / protective layer (around the earth) 7

(j) Give the quark composition of the neutron. (7)

reference to three quarks (4)

up, down, down (udd) 7

or **List two factors that affect the efficiency of a transformer. (7)**

eddy currents (in the iron core) / heat or energy losses in the (low voltage) coil / shape of core / core laminations, etc. any two 4+3

Question 6

Define (i) force, (ii) momentum. (12)

force is what causes acceleration / change in $\bar{v}$ / change in momentum 6

(change in speed / direction; $F=ma$ … 3 marks)

momentum = mass × velocity (= $m \times v$) 6

State Newtons second law of motion.
Hence, establish the relationship: force = mass × acceleration. (15)

rate of change of momentum is proportional to // formula 3

applied force and takes place in the direction of the force // notation (for u, v) 3

(no reference to direction … -1)

$F \propto m\frac{\Delta v}{\Delta t} / \frac{mv - mu}{t} / m\frac{v-u}{t} / ma$ 3

$F = kma$ 3

$k = 1 \Rightarrow F = ma$ 3

A pendulum bob of mass 10 g was raised to a height of 20 cm and allowed to swing so that it collided with a block of mass 8.0 g at rest on a bench. The bob stopped on impact and the block subsequently moved along the bench. Calculate:
(i) the velocity of the bob just before the collision;
(ii) the velocity of the block immediately after the collision. (18)

(i) $mgh = \frac{1}{2}mv^2$ / (loss in) P.E = (gain in) K.E // $v^2 = u^2 + 2as$ 3

$v^2 = 2gh$ / 2(9.8)(0.2) // $v^2 = 2as / 2(9.8)(0.20)$ 3

v = 1.98 m s^{-1} (≈2.0 m s^{-1}) **(-1 for omission of or incorrect unit)** 3

(For stand-alone E_k and E_p formulae … 3)

(ii) $m_1v_1 = m_2v_2$ // reference to conservation of momentum 3

$(0.01)(2) = (0.008)v_2$ 3

v_2 = 2.475 (m s^{-1}) (≈ 2.5 m s^{-1}) 3

The block moved 2.0 m along the bench before stopping. What was the average horizontal force exerted on the block while travelling this distance? (11)

$v^2 = u^2 + 2as$ / 0 = (2.5)^2 + 2a(2) // work done (W) = E_k 3

$|a|$ = 1.563 m s^{-2} (≈1.6 m s^{-2}) // $W = F \times s$ 3

$F = ma$ / (0.008)(1.6) // $F = \frac{\frac{1}{2}mv^2}{s}$ or $\frac{\frac{1}{2}(8.0\times10^{-3})(2.5)^2}{2}$ 3

F = 0.0128 N (≈ 0.013 N) // F = 0.0125 N (≈ 0.013 N) 2

accept range: 0.012 – 0.013 N
(-1 for omission of or incorrect unit in final answer)

Question 7

Define (i) specific heat capacity, (ii) specific latent heat. (12)

(i) energy required to raise (the temperature) // $c = \frac{\Delta E}{m\Delta\theta}$ 3
of 1 kg (of a substance) by 1 K // notation 3

(ii) energy required to change the state (or e.g. ice to water) 3
of 1 kg (of a substance) without a change in temperature 3
(-1 for omission of 'without a change in temperature')

500 g of water at a temperature of 15 °C is placed in a freezer. The freezer has a power rating of 100 W and is 80% efficient.
(i) Calculate the energy required to convert the water into ice at a temperature of -20 °C.
(ii) How much energy is removed every second from the air in the freezer?
(iii) How long will it take the water to reach a temperature of -20 °C? (27)

(i) (cooling from 15 °C to 0 °C:) $Q = mc\Delta\theta$ 3
$\Rightarrow Q_1 = (0.5)(4200)(15)$ / = 31500 (J) 3
(change of state:) $Q = ml$ 3
$\Rightarrow Q_2 = (0.5)(3.3 \times 10^5)$ / =165000 (J) 3
(cooling ice from 0 °C to -20 °C :) $\Rightarrow Q_3 = (0.5)(2100)(20)$ / =21000 (J) 3
total energy required = $Q_t = Q_1 + Q_2 + Q_3$ / =217500 / =2.2×10^5 J 3
(-1 for omission of or incorrect unit in final answer)

(ii) (80% efficiency $\Rightarrow$ 80 W $\Rightarrow$) 80 J (per second) 3
(-1 for omission of or incorrect unit)

(iii) power = Q ÷ time 3
t = (217500 ÷ 80) s / 2700 s / 45 m 3
(-1 for omission of or incorrect unit)

Allowing a liquid to evaporate in a closed pipe inside the freezer cools the air in the freezer. The vapour is then pumped through the pipe to the outside of the freezer, where it condenses again. Explain how this process cools the air in the freezer. (12)

evaporation requires latent heat / (this) change of state requires energy 6
which is taken from inside the freezer / and this lowers the temperature 6

The freezer causes the room temperature to rise. Explain why. (5)

condensation / vapour to liquid, releases latent heat 5

Question 8

Define (i) potential difference, (ii) capacitance. (12)

(i) work done // $\frac{W}{Q}$ 3

per unit charge // notation 3

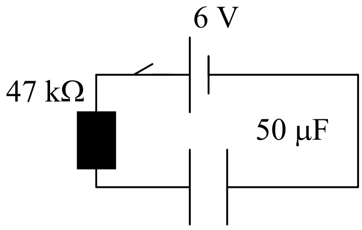
(ii) charge (stored) // $\frac{Q}{V}$ 3

per unit volt // notation 3

Describe an experiment to demonstrate that a capacitor can store energy. (12)

apparatus: capacitor, cell, bulb / wire (for shorting C) 3
connect cell to capacitor / charge capacitor 3
connect bulb across capacitor // short terminals of capacitor 3
bulb lights // spark 3

The circuit diagram shows a 50 μF capacitor connected in series with a 47 kΩ resistor, a 6 V battery and a switch. When the switch is closed the capacitor starts to charge and the current flowing at a particular instant in the circuit is 80 μA. Calculate:



(i) **the potential difference across the resistor and hence the potential difference across the capacitor when the current is 80 μA;**
(ii) **the charge on the capacitor at this instant;**
(iii) **the energy stored in the capacitor when it is fully charged. (27)**

(i) $V = IR$ 3

$V = (80\times10^{-6})(47\times10^{3})$ 3

$\Rightarrow V = 3.76$ V for resistor 3

$V_c = 6 - 3.76$ 3

$\Rightarrow V_c = 2.24$ V for capacitor 3

(-1 for omission of or incorrect unit .. penalise once only)

(ii) $Q = CV$ / $Q = (50\times10^{-6})(2.24)$ 3

$Q = 1.12 \times 10^{-4}$ C **(-1 for omission of or incorrect unit)** 3

(iii) $E = \frac{1}{2}CV^2$ / $E = \frac{1}{2}(50\times10^{-6})(6)^2$ 3

$E = 9\times10^{-4}$ J **(-1 for omission of or incorrect unit)** 3

Describe what happens in the circuit when the 6 V d.c. supply is replaced with a 6 V a.c. supply. (5)

charge / current flows // C charges 3
all of the time / forwards and backwards // discharges 2
("*C conducts all of the time*"… 5. "C conducts" … (5-1) =4)

Question 9

Distinguish between photoelectric emission and thermionic emission. (12)

P.E.E.: emission of electrons // T.I.E.: emission of electrons 3+3
light (of suitable frequency) falls on a metal // from (surface of) hot metal 3+3

A freshly cleaned piece of zinc metal is placed on the cap of a negatively charged gold leaf electroscope and illuminated with ultraviolet radiation. Explain why the leaves of the electroscope collapse. (9)

photoelectric emission (or effect) occurs / electrons emitted 6
leaves become uncharged (and collapse) / repulsion between leaves lessens / p.d. between leaves and chassis decreases 3

Explain why the leaves do not collapse when:
(i) the zinc is covered by a piece of ordinary glass;
(ii) the zinc is illuminated with green light;
(iii) the electroscope is charged positively. (15)

(i) ordinary glass does not transmit UV light 3

(ii) no electrons emitted / photoelectric effect does not occur 3
E or *f* too low / λ too long / work function of metal not overcome 3

(iii)(any) electron emitted // no electron emitted 3
attracted back to the positive electroscope // charge on leaves is constant 3

The zinc metal is illuminated with ultraviolet light of wavelength 240 nm. The work function of zinc is 4.3 eV. Calculate:
(i) the threshold frequency of zinc;
(ii) the maximum kinetic energy of an emitted electron. (20)

(i) $\phi = hf_0$ / $hf = \phi + \frac{1}{2}mv^2$ / $hf = hf_o + E_k$ / any correct format 3

$f_0 = \frac{(4.3)(1.6\times10^{-19})}{6.6\times10^{-34}}$ or $f_0 = 1.04\times10^{15}$ Hz 3

(-1 for omission of or incorrect unit)

(ii) $c = f\lambda$ 3

$f = \frac{(3\times10^{8})}{(240\times10^{-9})}$ 3

$f = 1.25\times10^{15}$ (Hz) 3

$E_k = hf - \phi$ 3

$E_k = (6.6\times10^{-34})[(1.25\times10^{15})-(1.04\times10^{15})]$ / $1.386\times10^{-19} \approx 1.39\times10^{-19}$ J 2

(-1 for omission of or incorrect unit)

Question 10(a)

Beta decay is associated with the weak nuclear force. List two other fundamental forces of nature and give one property of each force. (12)

strong (nuclear) force /gravitational force /electromagnetic force any two: 3 + 3

strong: acts on nucleus/protons + neutrons/hadrons/baryons/mesons, short range
gravitational: attractive force, inverse square law/infinite range, all particles
electromagnetic: acts on charged particles, inverse square law/infinite range
one property of each of the *two other* fundamental forces listed: 3 + 3

In beta decay, a neutron decays into a proton with the emission of an electron. Write a nuclear equation for this decay. Calculate the energy released during the decay of a neutron. (21)

${}^{1}_{0}n \rightarrow {}^{1}_{1}p + {}^{0}_{-1}e$ 3+3+3

$(n \rightarrow p + e)$.. 3 only. –1 for each incorrect mass/atomic number

mass lost = mass before – mass after / reference to mass defect 3

$\Delta m = 1.3891 \times 10^{-30}$ kg 3

$E = mc^2$ 3

$E = (1.3891 \times 10^{-30})(2.9979 \times 10^{8})^2$ / 1.2484×10^{-13} / 1.25×10^{-13} J 3

(-1 for omission of or incorrect unit)

Momentum and energy do not appear to be conserved in beta decay. Explain how the existence of the neutrino, which was first named by Enrico Fermi, resolved this. (8)

"missing" momentum provided by the neutrino 4
"missing" energy provided by the neutrino 4
("*momentum and energy are conserved when the momentum and energy of the (associated) neutrino are taken into account*". 4 + 4)

During the late 1930's Fermi continued to work on the nucleus. His work led to the creation of the first nuclear fission reactor in Chicago during 1942. The reactor consisted of a 'pile' of graphite moderator, uranium fuel with cadmium control rods. (15)

(i) What is nuclear fission?
splitting of a large nucleus 3
into two similar-sized/smaller nuclei + energy (-1 per missing item) 3
(–1 if *atom* used instead of *nucleus*)

(ii) What is the function of the moderator in the reactor?
slows down fast neutrons (-1 if *fast* omitted) 6

(iii) How did the cadmium rods control the rate of fission?
(they) absorbed neutrons 3

Question 10(b)

A current-carrying conductor experiences a force in a magnetic field. Name the factors that affect the magnitude of the force? (9)

(magnetic) flux density, current, length, $\sin\theta$ / θ any three items 3+3+3

Describe a laboratory experiment to demonstrate the principle that a current-carrying conductor in a magnetic field experiences a force. (12)

apparatus: battery, magnet, conductor, switch (stated/implied) 3
procedure: send current through conductor (in a magnetic field) 3
result: conductor moves 3
conclusion /any point of detail (e.g. F in opposite direction if current reversed) 3

The operation of a moving coil meter is based on this principle. List two other devices based on this principle. (6)

loudspeaker, d.c.motor, Barlow's wheel, etc. any two: 3+3
(ammeter, voltmeter, etc. unacceptable)

What is the function of a moving coil galvanometer? Draw a circuit diagram to show how a moving coil galvanometer can be converted into an ammeter. (9)

to measure or detect (very) small currents / to indicate direction of I or V 3

diagram showing galvanometer and resistor 3
in parallel 3

A moving coil galvanometer has a resistance of 100 Ω and a full-scale deflection of 5.00 mA. Calculate the size of the resistor required to convert it into an ammeter with a full-scale deflection of 1.00 A.
What is the effective resistance of the ammeter? (15)

current through resistor = 0.995 A 3
$V_R = V_G$ / $(0.995)R = (0.005)(100)$ 3
$R = 0.50(3)\ \Omega$ 3

$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$ 3
$\frac{1}{R_t} = \frac{1}{0.503} + \frac{1}{100}$ / $R_t = 0.500\ \Omega$ 3
(-1 for omission of or incorrect unit -- penalise once only)

Why does the magnet in a moving coil galvanometer have curved pole faces? (5)

to give a radial magnetic field / torque on coil is constant / $\theta \propto I$ / to give a uniform scale / arm of couple remains constant 5

Question 11 Answer all of the following.

(a) Name and give the colour of the wire that should be connected to the fuse in a standard three-pin plug. (7)

live / phase 4
brown / red 3

(b) Explain why replacing a fuse with a piece of aluminium foil is dangerous. (7)

does not melt /break // can carry a very large current 4
if too large a current flows // fire / (fatal) shock 3

(c) A table lamp has a power rating of 100 W. What is the most suitable fuse for the lamp? (7)

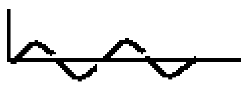
$I = \frac{P}{V}$ / $I = \frac{100}{230}$ (4)
range: 0.5 A $\leftrightarrow$ 5 A fuse 7

(d) Some electrical appliances are supplied with two pin plugs. Why is an earth wire not required in these devices? (7)

(all) external parts 4
electrical insulators / non-conducting / named insulator 3
'appliance is doubly insulated' (7); 'no danger/risk of shock' (4)

(e) Sketch a voltage-time graph of the 230 V supply. (7)

varying voltage 4
sinusoidal waveform 3
(-1 if at least one full cycle is not shown: -1 if no nega



(f) Explain how a Residual Current Device (RCD) operates. (7)

measures/detects current in live and neutral 4
trips/shuts off if there is a difference(between them) 3

(g) Give one advantage of a Residual Current Device (RCD) over a Miniature Circuit Breaker (MCB). (7)

RCD responds v. quickly / RCD responds to tiny currents 7
RCD prevents electrocution / is safer ... (4)

(h) Storage heaters have a large heat capacity. Explain why. (7)

they are heated (only) at night / use cheap (night) tariff /contain material of high specific heat capacity/ (must) release energy slowly(or during the day) 7

Question 12: Answer any two parts

Question 12(a)

State Newton's universal law of gravitation. (6)

force $\propto$ product of masses // correct expression 3

inversely proportional to distance squared // explain notation 3

Centripetal force is required to keep the earth moving around the sun. (10)

(i) What provides this centripetal force?

gravitational force/pull of the sun (on the earth) 4

(ii) In what direction does this centripetal force act?

towards the sun / centre (of orbit) 3

(iii) Give an expression for centripetal force.

$F = \frac{mv^2}{d}$ / $m\omega^2 d$ 3

The earth has a speed of 3.0 × 10^4 m s^-1 as it orbits the sun. The distance between the earth and the sun is 1.5 × 10^11 m. Calculate the mass of the sun. (12)

$[F =]\frac{GM_s M_e}{d^2} = \frac{M_e v^2}{d}$ // $T^2 = \frac{4\pi^2 R^3}{GM}$ 3

$M_s = \frac{v^2 d}{G}$ // $T = 365$ days / 3.15×10^7 s 3

$M_s = \frac{(3.0\times10^4)^2(1.5\times10^{11})}{6.7\times10^{-11}}$ // $M_s = \frac{4\pi^2(1.5\times10^{11})^3}{(6.7\times10^{-11})(3.15\times10^7)^2}$ 3

$M_s = 2.0 \times 10^{30}$ kg // $M_s = 2.0 \times 10^{30}$ kg 3

(-1 for omission of or incorrect units)

Question 12(b)

Give two reasons why the telecommunications industry uses optical fibres instead of copper conductors to transmit signals. (6)

less interference / boosted less often / cheaper raw material / occupy less space / more information (carried) in the same space / flexible for inaccessible places/ do not corrode, etc. any two 3+3

Explain how a signal is transmitted along an optical fibre. An optical fibre has an outer less dense layer of glass. What is the role of this layer of glass? (13)

light ray/signal introduced at one end of fibre; … (stated or implied) 3

strikes interface/boundary at $i > i_c$ 3

total internal reflection occurs 3

(-1 if no reference to light)

signal/light (then always) remains in denser medium / t.i.r. occurs / prevents light passing from one fibre to an adjacent one / prevents light escaping / prevents damage to surface of the core, etc. 4

An optical fibre is manufactured using glass of refractive index of 1.5. Calculate the speed of light travelling through the optical fibre. (9)

$n_g = \frac{c_a}{c_g}$ or $\frac{c_1}{c_2}$ 3

$1.5 = \frac{3\times10^8}{v_g}$ 3

$v_g = 2.0 \times 10^8$ (m s^{-1}) 3

Question 12(c)

What is electromagnetic induction?
Describe an experiment to demonstrate electromagnetic induction. (15)

conductor cuts magnetic flux / (changing) magnetic flux cutting conductor 3
emf induced 3

arrangement: coil and galvanometer in series 3
procedure: move magnet towards coil 3
result: galvanometer indicates a current / G kicks 3

A light aluminium ring is suspended from a long thread as shown in the diagram. When a strong magnet is moved away from it, the ring follows the magnet. Explain why.
What would happen if the magnet were moved towards the ring? (13)

electromagnetic induction / emf induced in ring / changing flux or field 3
current flows (in ring) 3
in such a direction as to oppose change / ring follows magnet by Lenz's law 3

ring repelled / moves away 4

Question 12(d)

A p-n junction is formed by taking a single crystal of silicon and doping separate but adjacent layers of it. A depletion layer is formed at the junction. (15)

(i) What is doping?
adding a (controlled) quantity of an impurity (to the crystal) / Al / P / etc. 3
to increase conduction / to form p- / n-type material 3

(ii) Explain how a depletion layer is formed at the junction.
electrons from n-type and/or holes from p-type 3
cross junction 3
(narrow) charged region acts as a 'barrier' or depletion layer 3
(correctly labelled diagram 3 × 3)

The graph shows the variation of current *I* with potential *V* for a p-n junction in forward bias. (13)

Explain, using the graph, how the current varies with the potential difference.
very little current flows between 0 V and 0.6 V 3
> 0.6 V a large current flows 3

Why does the p-n junction become a good conductor as the p.d exceeds 0.6 V?
the depletion layer / barrier potential / junction voltage // width of depletion layer 4
is overcome // reduced 3
["*(effective) resistance lowered* (4) *and this results in a larger current flow*" 7]