SCIENCE (PHYSICS) – Paper 2 Physics (set 2.10) – mark scheme

Use this to mark your own attempt. Accept any correct alternative that answers the question as set. Marks are for the ideas, not the exact words. Unless stated, ecf (error carried forward) applies in calculations. Chermistry practice paper – not an official examination paper.

Total marks: 65 (Section A: 55 marks; Section B: one question of 10 marks)

Textbook references are quoted word for word from *Discover Physics, 5th ed*.

Section A – Question 1 [2]

Part	Answer and mark points	Marks
1(a)	• conversions: 0.15 nm = 1.5×10^{-10} m; 1.5 cm = 0.015 m; 0.12 km = 120 m; 12 700 km = 1.27×10^{7} m • orders of magnitude: carbon atom 10^{-10} m; tuning peg 10^{-2} m; observation wheel 10^{2} m; Earth 10^{7} m • all four correct (2); any two or three correct (1). The conversions need not be shown **Accept:** the orders of magnitude written as powers of ten without the unit m. NOT: 10^{-14} m or 10^{-6} m for any length (these are distractors: 10^{-14} m is about the size of a nucleus, 10^{-6} m about the size of a bacterium). Common errors: nano taken as 10^{-6} (giving 10^{-7} m for the atom) or kilo taken as 10^{6}	2

Section A – Question 2 [5]

Part	Answer and mark points	Marks
2(a)	• total distance = 45 + 24 = 69 m; average speed = total distance / total time = 69 / 6.0 (1) • **11.5 m/s** (1) **Accept:** 11 m/s, 12 m/s (2 s.f.). NOT: 0.5 × 30 = 15 m/s (the average of the maximum speed and zero is wrong for the whole motion). 1 mark for 69 / 6.0 with a wrong distance sum only if the working is shown (ecf)	2
2(b)	• gradient = 30 / 3.0 = 10 m/s^2, which is the (approximate) value of the acceleration of free fall (1) • the line is straight, so the acceleration of free fall is constant (does not change as the cabin falls) (1) **Accept:** speed gained each second = 10 m/s per second. Allow a comparison with 9.8 m/s^2 (the book gives 9.8 m/s^2, and 10 m/s^2 for calculations). NOT: the acceleration increases because the speed increases **Textbook: Discover Physics, 5th ed., p. 38 (Ch 2 Kinematics, 2.3)** > *"Acceleration due to gravity g is a constant."*	2
2(c)	the acceleration is non-uniform: the (magnitude of the) deceleration gets smaller (the gradient of the curve becomes less steep) as time goes on (1) **Accept:** the change in speed every second is not the same / the gradient is changing. NOT: the cabin slows at a steady rate **Textbook: Discover Physics, 5th ed., p. 26 (Ch 2 Kinematics, 2.2)** > *"An object undergoes non-uniform acceleration if the change in its velocity for every unit of time is not the same (Table 2.4)."*	1

Section A – Question 3 [5]

Part	Answer and mark points	Marks
3(a)	a measure of the amount of matter in a body (the car and driver) (1) **Accept:** how many atoms / particles of matter it contains. NOT: how heavy it is; NOT: the pull of the Earth on it **Textbook: Discover Physics, 5th ed., p. 49 (Ch 3 Force and Pressure, 3.2)** > *"Mass is a measure of the amount of matter in a body."*	1
3(b)	• weight (W) vertically downwards and normal (contact) force (R / N) vertically upwards, both from the dot and of equal length (1) • driving (forward) force F forwards and friction / resistive force f backwards, both along the horizontal from the dot, labelled and of equal length (1) **Accept:** allow air resistance as the label for the backward force. If the arrows in a pair are not equal in length, withhold that mark (constant speed means balanced forces). Each pair is worth one mark only if both forces are labelled	2
3(c)	• friction (between the wheels and the floor, and air resistance) acts opposite to the direction of motion (1) • with no driving force, friction is the only horizontal force / the resultant force is backwards, so the car decelerates (speed decreases) until it stops (1) **Accept:** any wording that links the slowing to the unbalanced friction / resistive force. NOT: the car stops because its forward force has run out (a force is not needed to keep it moving). NOT: friction is the same as the weight **Textbook: Discover Physics, 5th ed., p. 74 (Ch 4 Dynamics, 4.3)** > *"Friction is the contact force that opposes or tends to oppose motion between surfaces in contact."* **Textbook: Discover Physics, 5th ed., p. 74 (Ch 4 Dynamics, 4.3)** > *"If the applied force is removed, friction will cause the book to slow down and come to a stop eventually."*	2

Section A – Question 4 [3]

Part	Answer and mark points	Marks
4(a)	the (imaginary) point where the entire weight of the prop (object) seems to act (1) **Accept:** the single point through which the weight acts. NOT: the middle of the prop / the point where it is heaviest **Textbook: Discover Physics, 5th ed., p. 88 (Ch 5 Turning Effects of Forces, 5.3)** > *"The centre of gravity of an object is an imaginary point where the entire weight of the object seems to act."*	1
4(b)	when a body is in equilibrium, the sum of the **clockwise** moments about a pivot is equal to the sum of the **anticlockwise** moments about the same pivot (both words correct for the mark) (1) **Accept:** the words in either order if the sentence is still correct (for example anticlockwise ... clockwise). NOT: positive and negative **Textbook: Discover Physics, 5th ed., p. 85 (Ch 5 Turning Effects of Forces, 5.2)** > *"The principle of moments states that when a body is in equilibrium, the sum of clockwise moments about a pivot is equal to the sum of anticlockwise moments about the same pivot."*	1

4(c)	a straight (ruled) line from B through b, crossing the line A-a; the cross X at the point where the two lines meet (the centre of gravity is at the intersection of the lines) (1) **Accept:** X within 2 mm of the point where the line from B meets the line from A. NOT: X at the middle of the prop; NOT: a line drawn from B to a (the plumb line from B ends at b) **Textbook: Discover Physics, 5th ed., p. 89 (Ch 5 Turning Effects of Forces, 5.3 (Investigate 5A))** *"Place the lamina on the table and join the markings with straight dashed lines using a long rule (Figure 5.17)."* **Textbook: Discover Physics, 5th ed., p. 89 (Ch 5 Turning Effects of Forces, 5.3 (Investigate 5A))** *"Hang a plumb line from the pin in front of the lamina (Figure 5.16)."*	1

Section A – Question 5 [4]

Part	Answer and mark points	Marks
5(a)	• energy in the elastic potential store of the spring decreases and energy in the kinetic store of the ball increases (1) • as the ball rises the energy in its kinetic store decreases and energy in the gravitational potential store increases (1) **Accept:** ignore references to internal (thermal) stores as friction is ignored. Both stores must be named for the mark **Textbook: Discover Physics, 5th ed., p. 98 (Ch 6 Energy, 6.1)** *"Examples of stores of energy include kinetic, chemical potential, internal, gravitational potential, elastic potential and nuclear."* **Textbook: Discover Physics, 5th ed., p. 98 (Ch 6 Energy, 6.1)** *"A stretched rubber band or a compressed spring has energy in the elastic potential store (elastic potential energy)."*	2
5(b)	• $E_p = m\,g\,h = 0.080 \times 10 \times 0.20 = 0.16$ J gained, so the kinetic energy of the ball as it leaves the spring is 0.16 J (1) • $E_k = ½\,m\,v^2$: $v^2 = 2 \times 0.16 / 0.080 = 4.0$, so $v = \sqrt{4.0} =$ **2.0 m/s** (shown, with the unrounded value 4.0 or 2.0 seen) (1) **Accept:** all the kinetic energy at the start becomes gravitational potential energy at the top (conservation of energy). $v^2 = 2gh = 4.0$ also gets both marks. 1 mark for 0.16 J even if the second step is missing. No mark for a bare statement of 2.0 m/s or for working backwards from 2.0 m/s without a substitution	2

Section A – Question 6 [3]

Part	Answer and mark points	Marks
6(a)	• cymbal Y (1) • it has the higher temperature and temperature rises with the average kinetic energy of the particles (1) **Accept:** Y with its higher temperature given as the reason. NOT: X because it has more particles / more mass (the average, not the total, is asked) **Textbook: Discover Physics, 5th ed., p. 127 (Ch 7 Kinetic Particle Model of Matter, 7.2)** *"Temperature rises with the average kinetic energy of the particles in a body and vice versa."*	2

6(b)	internal energy is the total kinetic energy (of the random motion) and total potential energy of all the particles; X has twice as many particles, so its total energy is greater (1) **Accept:** must refer to the number of particles / total, not to the average. NOT: heat contained **Textbook: Discover Physics, 5th ed., p. 124 (Ch 7 Kinetic Particle Model of Matter, 7.1)** *"Internal energy is an energy store that is made up of the total kinetic energy associated with the random motion of the particles and the total potential energy between the particles in the system."*	1

Section A – Question 7 [3]

Part	Answer and mark points	Marks
7(a)	from the hotter end to the cooler end, until thermal equilibrium is reached (no more net transfer) (1; both the direction and the end state are needed) **Accept:** from higher temperature to lower temperature until both are at the same temperature **Textbook: Discover Physics, 5th ed., p. 134 (Ch 8 Thermal Processes, 8.1)** *"Energy is transferred from a region of higher temperature (hotter object) to a region of lower temperature (cooler object) until both regions have the same temperature."*	1
7(b)	• in both materials, particles at the hot end vibrate more and pass energy to neighbouring particles by vibration (collisions) (1) • copper also has free electrons which move quickly through the metal and transfer energy to the particles at the cooler end; plastic has none, so copper conducts faster (1) **Accept:** the small size / high speed of free electrons. NOT: copper atoms move along the rod **Textbook: Discover Physics, 5th ed., p. 136 (Ch 8 Thermal Processes, 8.2)** *"Conduction is a process of energy transfer where energy is transferred through the passing on of vibrational motion from one particle to another."* **Textbook: Discover Physics, 5th ed., p. 137 (Ch 8 Thermal Processes, 8.2)** *"In addition to the same process in non-metals, the free electrons at this heated end gain energy from interacting with the particles."*	2

Section A – Question 8 [5]

Part	Answer and mark points	Marks
8(a)	**2.5 ms** (time for one complete cycle, read from successive peaks or from the start and end of one cycle) (1) **Accept:** 2.5 ms (0.0025 s); 2.4 to 2.6 ms. NOT: 1.25 ms (half a cycle) **Textbook: Discover Physics, 5th ed., p. 161 (Ch 9 General Wave Properties I, 9.3)** *"The period T is the time taken by each point on the wave to complete one oscillation."*	1
8(b)	• frequency = 1 / period = 1 / 0.0025 = 400 Hz (1) • $v = f\lambda$ so λ = 340 / 400 = **0.85 m** (1) **Accept:** ecf from the period read in (a). If the period is left in ms (f = 1 / 2.5 = 0.4, λ = 340 / 0.4 = 850 m) allow 1 mark for the correct method, f = 1 / T then v = fλ. Allow 340 × 0.0025 = 0.85 m	2

8(c)	• louder: a sketched wave with a greater amplitude than note A (peaks higher than 20 mV and troughs lower than −20 mV) (1) • lower pitch: a smaller frequency, so a longer period than note A (more than 2.5 ms for one complete cycle; fewer than 2.4 cycles in 6.0 ms) (1) **Accept:** the wave need not be accurate in shape but must be periodic and of a constant amplitude; it must stay inside the grid. NOT: a wave with a larger amplitude and a shorter period (higher pitch); NOT: a wave of the same amplitude as note A **Textbook: Discover Physics, 5th ed., p. 175 (Ch 10 General Wave Properties II - Sound, 10.2)** *"The larger the amplitude, the louder the sound."* **Textbook: Discover Physics, 5th ed., p. 175 (Ch 10 General Wave Properties II - Sound, 10.2)** *"The higher the frequency, the higher the pitch."*	2

Section A – Question 9 [3]

Part	Answer and mark points	Marks
9(a)(i)	remote controller for the stage lights / television; heating (keeping warm); data transfer; night vision (any one) (1) **Accept:** any typical use. NOT: tanning; X-ray pictures **Textbook: Discover Physics, 5th ed., p. 190 (Ch 11 Electromagnetic Waves, 11.2)** *"Devices such as the television and air conditioners can be remotely turned on or off using an infrared remote controller."*	1
9(a)(ii)	checking a security (anti-forgery) mark on a ticket or wristband; sterilisation; sunbed (any one) (1) **Accept:** any typical use. NOT: cooking food; satellite television **Textbook: Discover Physics, 5th ed., p. 192 (Ch 11 Electromagnetic Waves, 11.2)** *"As an anti-forgery feature, part of the note will glow when illuminated with ultraviolet light."*	1
9(b)	sunburn / premature ageing of the skin / higher risk of skin cancer (any one) (1) **Accept:** damage to skin cells or eyes. NOT: the person becomes radioactive **Textbook: Discover Physics, 5th ed., p. 195 (Ch 11 Electromagnetic Waves, 11.3)** *"Sun burn is the most common effect of over-exposure to electromagnetic radiation, specifically caused by too much ultraviolet radiation. Frequent sunburns can cause premature skin aging and higher risk of skin cancer."*	1

Section A – Question 10 [5]

Part	Answer and mark points	Marks
10(a)	• sin i / sin r = n: sin r = sin 40° / 1.33 = 0.483 (1) • r = **29°** (28.9°) (1) **Accept:** 28.9°, 29°. NOT: 40 / 1.33 = 30° (angles must not be divided; the sines are used)	2
10(b)	29°: the angle of reflection is equal to the angle of incidence, and the angle of incidence at the mirror is the angle of the beam to the normal, 29° (1) **Accept:** ecf from (a). NOT: 40° **Textbook: Discover Physics, 5th ed., p. 202 (Ch 12 Light, 12.1)** *"The second law of reflection states that the angle of incidence θi is equal to the angle of reflection θr."*	1

10(c)	• the distance between the optical centre of the lens and the principal focus (1) • the principal focus is the point on the principal axis where rays parallel to the principal axis meet (converge) after passing through the lens (1) **Accept:** focal length = distance from the lens centre to the point where parallel rays are focused. NOT: the distance from the object to the lens **Textbook: Discover Physics, 5th ed., p. 216 (Ch 12 Light, 12.3)** *"The distance between the optical centre C and the principal focus point F"* **Textbook: Discover Physics, 5th ed., p. 216 (Ch 12 Light, 12.3)** *"The point on the principal axis where all rays parallel to the principal axis meet after passing through the lens"*	2

Section A – Question 11 [4]

Part	Answer and mark points	Marks
11(a)	• the sum of the potential differences across the components in a series circuit equals the p.d. across the whole circuit (supply) (1) • p.d. across R = 9.0 − 2.5 − 3.5 = **3.0 V** (1) **Accept:** sum of p.d.s = battery p.d. NOT: the p.d. is the same across each component **Textbook: Discover Physics, 5th ed., p. 253 (Ch 14 D.C. Circuits, 14.1)** *"The sum of the potential differences in a series circuit is equal to the potential difference across the whole circuit."*	2
11(b)	• parallel group: 1 / R = 1 / 20 + 1 / 30 + 1 / 60 = 6 / 60, so R = 10 Ω (1) • total = 10 + 8.0 = **18 Ω** (1) **Accept:** allow 18.0 Ω. NOT: 20 + 30 + 60 + 8.0 = 118 Ω. 1 mark for the correct method if the sum of the reciprocals is not inverted (ecf)	2

Section A – Question 12 [4]

Part	Answer and mark points	Marks
12(a)(i)	electric shock (the water is a good conductor, so a current can pass through the technician to the ground) (1) **Accept:** electrocution. NOT: the lamp goes out; NOT: the cloth gets hot **Textbook: Discover Physics, 5th ed., p. 275 (Ch 15 Practical Electricity, 15.2)** *"Water usually contains charged ions and impurities that make it a good conductor of electricity. Hence, many electrical accidents occur in damp environments."*	1
12(a)(ii)	overheating of the cable (large current in a coiled cable) which can cause a fire (1) **Accept:** melting of insulation. NOT: electric shock only **Textbook: Discover Physics, 5th ed., p. 275 (Ch 15 Practical Electricity, 15.2)** *"Overheated circuits can cause fire and even explosions."*	1
12(b)	• with the switch in the neutral wire, the lamp is still connected to the live wire (the mains) when the switch is open, so the casing / lamp can still be at a high potential (live), for example if the live wire comes loose and touches the casing (1) • a switch in the live wire disconnects the lamp from the live wire when it is open, so no closed path (no shock) is formed (1) **Accept:** the same reasoning for fuses and circuit breakers. NOT: because the live wire has the larger current; NOT: because the neutral wire is not dangerous **Textbook: Discover Physics, 5th ed., p. 281 (Ch 15 Practical Electricity, 15.4)** *"Switches and safety features such as fuses and circuit breakers have to be connected to the live wire in order to break or complete a circuit. Consider the case in Figure 15.19 where the switch is connected to the neutral wire instead. Then the appliance becomes "live" and can create an electric shock when a person touches it even when the switch is open."*	2

Section A – Question 13 [5]

Part	Answer and mark points	Marks
13(a)	• steel is a magnetic material and becomes magnetised (an induced magnet) when placed close to a strong magnet (1) • the end of the string nearest the north pole becomes a south pole (opposite pole), and unlike poles attract (1) **Accept:** induced magnetism. NOT: the string is made of a metal so all metals are attracted **Textbook: Discover Physics, 5th ed., p. 291 (Ch 16 Magnetism and Electromagnetism, 16.2)** > *"Induction, or induced magnetism, can take place when a magnetic material is placed close to a strong magnet or within a current-carrying solenoid."*	2
13(b)	iron (a soft magnetic material): it is easily magnetised and demagnetised (a temporary magnet), so it loses its magnetism when the current stops; steel keeps its magnetism (a permanent magnet) (1; the material and the reason are both needed) **Accept:** iron as the core, used for electromagnets. NOT: steel; NOT: iron because it is a magnetic material (steel is also magnetic) **Textbook: Discover Physics, 5th ed., p. 294 (Ch 16 Magnetism and Electromagnetism, 16.2)** > *"Temporary magnets retain their magnetism in the presence of an electric current or a permanent magnetic field."* **Textbook: Discover Physics, 5th ed., p. 294 (Ch 16 Magnetism and Electromagnetism, 16.2)** > *"Iron and steel are examples of soft and hard magnetic materials, respectively."*	1
13(c)(i)	all four needles drawn as arrows along the circle around the cable (tangent to the circle), pointing clockwise: right at the top compass, down at the right-hand compass, left at the bottom compass, up at the left-hand compass (1) **Accept:** allow a small error in the angle; all four are needed. NOT: arrows pointing towards or away from the cable; anticlockwise arrows **Textbook: Discover Physics, 5th ed., p. 304 (Ch 16 Magnetism and Electromagnetism, 16.4)** > *"The directions of the needles on the compasses follow the right-hand grip rule. If we grip the conductor with our thumb pointing in the direction of the conventional current, the curl of the fingers shows the direction of the magnetic field (Figure 16.41)."*	1
13(c)(ii)	the needles turn to point in the opposite direction (each reverses, now anticlockwise) and the magnetic field becomes stronger (both needed) (1) **Accept:** the field direction is reversed and the field strength increases. NOT: the needles stay in the same direction; NOT: the field becomes weaker **Textbook: Discover Physics, 5th ed., p. 304 (Ch 16 Magnetism and Electromagnetism, 16.4)** > *"If the direction of the current is reversed, the needles deflect in the opposite direction (Figure 16.40)."* **Textbook: Discover Physics, 5th ed., p. 305 (Ch 16 Magnetism and Electromagnetism, 16.4)** > *"The strength of magnetic field increases when the current is increased (Figure 16.42)."*	1

Section A – Question 14 [4]

Part	Answer and mark points	Marks
14(a)	• decay is spontaneous: it is not affected by external factors such as temperature, so warming does not change the rate of emission (1) • decay is random: it cannot be predicted which nucleus will decay or when (the direction and time between emissions cannot be predicted), so the second claim is also wrong (1) **Accept:** an unstable nucleus loses energy by emitting radiation. NOT: random means that all nuclei decay together **Textbook: Discover Physics, 5th ed., p. 323 (Ch 17 Radioactivity, 17.2)** *"In other words, it is not possible: to make the radioactive nucleus emit radiation by heating, cooling, chemical means or any other method;"* **Textbook: Discover Physics, 5th ed., p. 323 (Ch 17 Radioactivity, 17.2)** *"Nuclear decay is a random process by which an unstable atomic nucleus loses its energy by emission of electromagnetic radiation or particle(s)."* **Textbook: Discover Physics, 5th ed., p. 323 (Ch 17 Radioactivity, 17.2)** *"The direction of the emissions and the time between emissions cannot be predicted."*	2
14(b)	• alpha: two protons and two neutrons (a helium nucleus); beta: fast-moving electron from the nucleus; gamma: electromagnetic radiation (wave) from the nucleus; all three correct (1) • ionising effect: alpha highest, beta medium, gamma lowest (all three correct) (1) **Accept:** helium nucleus. Beta described simply as an electron is allowed. NOT: an electron from the electron shell **Textbook: Discover Physics, 5th ed., p. 324 (Ch 17 Radioactivity, 17.2)** *"An α-particle consists of two protons and two neutrons tightly bound together."* **Textbook: Discover Physics, 5th ed., p. 324 (Ch 17 Radioactivity, 17.2)** *"An β-particle is a fast-moving electron ejected from a radioactive nucleus."* **Textbook: Discover Physics, 5th ed., p. 324 (Ch 17 Radioactivity, 17.2)** *"A γ-ray is electromagnetic radiation emitted by a nucleus with excess energy."*	2

Section B – Question 15 [10]

Part	Answer and mark points	Marks
15(a)	• total mass = 52 + 4.0 = 56 kg; $W = m\,g$ = 56 × 10 (1) • **560 N** (1) **Accept:** 520 N + 40 N. NOT: 520 N (the prop omitted). 1 mark for 56 kg or 560 N seen **Textbook: Discover Physics, 5th ed., p. 50 (Ch 3 Force and Pressure, 3.2)** *"Weight is the gravitational force acting on an object that has mass."*	2
15(b)(i)	• area = 9.0 cm^2 = 9.0 × 10^{-4} m^2; $p = F / A$ = 560 / (9.0 × 10^{-4}) (1) • **6.2 × 10^5 N/m^2** (622 000 N/m^2) (1) **Accept:** ecf for the weight in (a). 6.2 × 10^5 Pa. NOT: 560 / 9.0 = 62 (area not converted). 1 mark for 560 / 9.0 × 10^{-4} with a wrong evaluation **Textbook: Discover Physics, 5th ed., p. 57 (Ch 3 Force and Pressure, 3.4)** *"Pressure is the force acting per unit area."*	2
15(b)(ii)	yes, the floor is damaged, because the pressure (6.2 × 10^5 N/m^2) is greater than 3.0 × 10^5 N/m^2 (1) **Accept:** ecf from (b)(i): a conclusion that agrees with the candidate's own comparison scores. NOT: a conclusion with no comparison of the two pressures	1

15(c)(i)	• conventional current arrow drawn clockwise (leaving the positive terminal at the top of the battery, through the lamp, then R, then the ammeter, back to the negative terminal) (1) • electron-flow arrow labelled *e* anticlockwise (opposite direction, towards the positive terminal) (1) **Accept:** allow a single arrow on any wire of the circuit for each. Both arrows in the same direction scores 0 for the second mark **Textbook: Discover Physics, 5th ed., p. 229 (Ch 13 Electric Charge and Current of Electricity, 13.2)** > *"Electron flow is opposite in direction to conventional current."*	2
15(c)(ii)	conventional current is defined as the flow of positive charges from the positive terminal to the negative terminal; electrons are negatively charged and flow from the negative terminal to the positive terminal (1) **Accept:** electrons were discovered after the convention was fixed. NOT: electrons flow faster **Textbook: Discover Physics, 5th ed., p. 228 (Ch 13 Electric Charge and Current of Electricity, 13.2)** > *"The direction of flow of positive charges is described as the conventional current, which assumes that positive charges flow out of the positive terminal of a battery to the negative terminal (Figure 13.6)."*	1
15(d)	• resistance = p.d. / current ($R = V / I$) (1) • R = 3.6 / 0.300 = **12 Ω**, so the label is correct (1) **Accept:** the mark for the relationship may be earned from the substitution. NOT: 3.6 / 300 = 0.012 (current not converted to amperes). ecf: a conclusion that agrees with the candidate's own value of R **Textbook: Discover Physics, 5th ed., p. 237 (Ch 13 Electric Charge and Current of Electricity, 13.4)** > *"The resistance R of a component is the ratio of the potential difference V across it to the current I flowing through it."*	2

Section B – Question 16 [10]

Part	Answer and mark points	Marks
16(a)	• M vibrates (moves up and down) perpendicular to the direction in which the wave travels, and returns to its starting position; it does not move along the rope (1) • energy is transferred along the rope, not matter (1) **Accept:** vibrates / oscillates / moves up and down about a fixed position. NOT: M moves along the rope with the wave **Textbook: Discover Physics, 5th ed., p. 156 (Ch 9 General Wave Properties I, 9.1)** > *"Waves can transfer energy without transferring matter."*	2
16(b)(i)	the sound wave travels to the wall and is reflected (by the hard surface) back to the conductor, who hears it a short time after the clap (1) **Accept:** the reflected sound is the echo. NOT: the sound bounces off the conductor **Textbook: Discover Physics, 5th ed., p. 176 (Ch 10 General Wave Properties II - Sound, 10.3)** > *"The reflected sound is called an echo."*	1
16(b)(ii)	• distance travelled by the sound = 2 × 51 = 102 m (to the wall and back) (1) • speed = distance / time = 102 / 0.30 = **340 m/s** (1) **Accept:** 340 m/s or 3.4 × 10^2 m/s. NOT: 51 / 0.30 = 170 m/s (the distance both ways was not used). 1 mark for 102 m only **Textbook: Discover Physics, 5th ed., p. 177 (Ch 10 General Wave Properties II - Sound, 10.3)** > *"With the speed of sound, computer-controlled sound emitter and sound sensor, the distance from the emitter to the reflecting surface can be easily calculated."*	2

16(c)	• first part is wrong: radio waves travel at 3×10^8 m/s, about $3 \times 10^8 / 340 = 9 \times 10^5$ times faster than sound (about a million times faster) (1) • second part is wrong: all electromagnetic waves (radio waves and light) travel at the same speed in a vacuum (1) • both are electromagnetic waves, which are transverse waves (1) **Accept:** ecf from (b)(ii) for the ratio (8.8×10^5). transverse or electromagnetic for the third mark. NOT: longitudinal **Textbook: Discover Physics, 5th ed., p. 185 (Ch 11 Electromagnetic Waves, 11.1)** > *"All electromagnetic waves are transverse waves."* **Textbook: Discover Physics, 5th ed., p. 185 (Ch 11 Electromagnetic Waves, 11.1)** > *"All electromagnetic waves can travel without a medium and they all travel at the same speed of 3×10^8 m/s in a vacuum."*	3
16(d)	• microwaves: longer wavelength, lower frequency; X-rays: shorter wavelength, higher frequency; radio waves: longer wavelength, lower frequency • all three wavelengths correct (1); all three frequencies correct (1) **Accept:** a mark for each fully correct column. NOT: a mark for a column with one entry wrong **Textbook: Discover Physics, 5th ed., p. 185 (Ch 11 Electromagnetic Waves, 11.1)** > *"In the electromagnetic spectrum, electromagnetic waves are arranged in order of their frequency or wavelength."*	2