© The Learning Cave

TEN-YEAR SERIES · ANSWERS AND WORKED SOLUTIONS

2023 O-Level Physics Paper 1

The question paper is © UCLES/SEAB and is not reproduced here — have your own copy of the paper open. The worked solutions are original work by The Learning Cave and are for personal study only.

ANSWER KEY

1 C	2 C	3 D	4 C	5 A	6 B	7 B	8 B	9 D	10 A
11 C	12 B	13 C	14 D	15 D	16 B	17 B	18 D	19 A	20 A
21 B	22 B	23 C	24 A	25 D	26 B	27 D	28 B	29 B	30 C
31 B	32 A	33 D	34 D	35 D	36 A	37 A	38 D	39 C	40 A

WORKED SOLUTIONS

Q1 Answer **C**

Why C is correct

Mass is the amount of matter in the stone. Nothing is added to the stone or taken from it when it is moved, so its mass is the same everywhere.

Weight is the gravitational force acting on the stone: $W = mg$. The mass m is unchanged, but g is different at the new place, so the weight changes.

Why the rest are wrong

A Requires the mass to change as well. Moving an object does not add or remove matter.

B Weight depends on g, so it cannot stay the same when g changes.

D This is the right idea applied to the wrong quantity — it is weight, not mass, that depends on where you are.

Watch out for

B. "Nothing was added or removed, so nothing changes" is half right: it settles the mass, not the weight. Say the two sentences separately — mass is fixed, weight follows g.

thelearningcave.com.sg
Physics. Math. chemistry.

Q2 Answer C

Why C is correct

Pressure is force per unit area: $p = F/A$.

Force in base units: $F = ma$, so $1\ \mathrm{N} = 1\ \mathrm{kg} \times 1\ \mathrm{m/s^2} = \mathrm{kg\ m/s^2}$.

Divide by area in m^2: $(\mathrm{kg\ m/s^2}) \div m^2 = \mathrm{kg/(m\ s^2)}$.

Why the rest are wrong

A $(\mathrm{kg\ m})/s^2$ is the base unit of force, not pressure — the division by area has been left out.

B kg/(m s) is short of one power of s; it comes from writing force as kg m/s.

D $\mathrm{kg/s^2}$ comes from dividing by a length instead of by an area.

Watch out for

A. Students who correctly recall $1\ \mathrm{N} = 1\ \mathrm{kg\ m/s^2}$ often stop there. Finish the job: pressure needs that divided by m^2.

Q3 Answer D

Why D is correct

The Earth's diameter is about $1.3 \times 10^7\ \mathrm{m}$, that is roughly 13 000 km. Since $1\ \mathrm{Mm} = 10^6\ \mathrm{m}$, this is of the order of 10 Mm.

An atom is about $1 \times 10^{-10}\ \mathrm{m}$ across. Since $1\ \mathrm{nm} = 10^{-9}\ \mathrm{m}$, this is 0.1 nm.

Why the rest are wrong

A Both wrong: $10\ \mathrm{Gm} = 10^{10}\ \mathrm{m}$ (about 70 times the Earth–Sun distance), and $0.1\mu m = 10^{-7}\ \mathrm{m}$ is about a thousand atoms wide.

B Atom is right, but 10 Gm is about a thousand times the Earth's actual diameter.

C Earth is right, but $0.1\mu m = 10^{-7}\ \mathrm{m}$ is nearer the size of a large virus than an atom.

Watch out for

B and C — each has one of the two right. Fix two anchors and the question answers itself: $\mathrm{Mm}(10^6\ \mathrm{m})$ for planet-sized things, $nm(10^{-9}\ \mathrm{m})$ for atom-sized things.

THE LEARNING CAVE
thelearningcave.com.sg
Physics. Math. Chemistry.

Q4 Answer C

Why C is correct

R is drawn from the top-left corner to the bottom-right corner. In a vector triangle the two components must take you from the tail of R to the head of R, following the arrows.

Starting at the top-left corner, the 3.0 N arrow must point DOWN the left-hand side to the bottom-left corner, and the 4.0 N arrow must then point RIGHT along the bottom to the head of R.

Only C has the vertical arrow pointing down and the horizontal arrow pointing right.

Check the size: $R = \sqrt{3.0^2 + 4.0^2} = 5.0\ \text{N}$, consistent with the triangle drawn.

Why the rest are wrong

A Both arrows are reversed — they take you from the head of R back to its tail the wrong way.

B The 4.0 N arrow is correct, but the 3.0 N arrow points up, breaking the tip-to-tail chain.

D The 3.0 N arrow is correct, but the 4.0 N arrow points left.

Watch out for

B and D — each has exactly one arrow right. Trace the route with a finger: you must be able to walk from the tail of R to its head along the two component arrows without ever walking backwards along one of them.

Q5 Answer A

Why A is correct

Average speed = total distance ÷ total time, and on a velocity–time graph the distance is the area under the line.

0 to 10 s — triangle: $\frac{1}{2} \times 10\ \text{s} \times 6.0\ \text{m/s} = 30\ \text{m}$

10 to 20 s — rectangle: $10\ \text{s} \times 6.0\ \text{m/s} = 60\ \text{m}$

20 to 30 s — trapezium: $\frac{1}{2} \times (6.0 + 10)\ \text{m/s} \times 10\ \text{s} = 80\ \text{m}$

Total distance = $30 + 60 + 80 = 170\ \text{m}$

Average speed = $170\ \text{m} \div 30\ \text{s} = 5.7\ \text{m/s}$

Why the rest are wrong

B 6.0 m/s is the velocity held during the middle section only; it is not an average over the whole 30 s.

C 6.3 m/s comes from 190 m ÷ 30 s — the last section taken as 10 m/s for the full 10 s (100 m) instead of the trapezium area of 80 m.

D 6.7 m/s comes from 200 m ÷ 30 s — the first section taken as 6.0 m/s for the full 10 s (60 m) instead of the triangle area of 30 m.

Watch out for

Reading an "average" off the height of the graph. A sloping section contributes only half of what a flat line at the same top value would. Work out the three areas separately and add them.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q6 Answer B

Why B is correct

Once the ball has left her hand, nothing is touching it. With air resistance ignored, the only force on it is its weight, acting downwards.

Newton's second law gives $a = F/m = mg/m = g = 10\ \mathrm{m/s^2}$, directed downwards.

This is true at every instant of the flight. At the highest point the VELOCITY is momentarily zero, but the velocity is still changing — from upwards to downwards — so the acceleration is not zero.

Why the rest are wrong

A Correct just after release, but says the acceleration is zero at the top. Zero velocity is not zero acceleration.

C Wrong on both counts — an upward acceleration would need an upward force, and her hand is no longer in contact with the ball.

D Says the acceleration is upwards just after release. There is no upward force acting once the ball is free.

Watch out for

A. "It stops at the top, so $a = 0$" is the commonest error in the whole topic. Ask instead: what force acts? Weight, downwards, for the entire flight — so $a = 10\ \mathrm{m/s^2}$ downwards for the entire flight.

Q7 Answer B

Why B is correct

At the instant of release the ball is at rest, so there is no air resistance. The resultant force is the full weight and the ball accelerates downwards at $10\ \mathrm{m/s^2}$.

As the ball speeds up, air resistance grows. The resultant force (weight minus air resistance) gets smaller, so the ACCELERATION decreases — but the ball is still gaining speed.

When air resistance has grown until it equals the weight, the resultant force is zero and the ball falls at a constant speed: terminal velocity.

Why the rest are wrong

A The ball never slows down. Its acceleration decreases, which is not the same as decelerating.

C It cannot be at constant velocity from the top — it starts from rest, so it must accelerate first.

D Its acceleration equals the acceleration of free fall only at the moment of release; after that air resistance reduces it, and at terminal velocity it is zero.

Watch out for

A, and the words "decreasing acceleration". Decreasing acceleration still means speeding up — just by a smaller amount each second.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q8 Answer B

Why B is correct

The two forces act along the same line in opposite directions, so the resultant is their difference:

Resultant = $10\ \text{N} - 5.0\ \text{N} = 5.0\ \text{N}$ to the right

$a = F/m = 5.0\ \text{N} \div 5.0\ \text{kg} = 1.0\ \text{m/s}^2$

Acceleration is always in the direction of the resultant force, so it is to the right.

Why the rest are wrong

A Right size, wrong direction. The resultant force is to the right, so the acceleration is too.

C $2.0\ \text{m/s}^2$ is 10 N ÷ 5.0 kg — the friction has been ignored — and the direction is wrong as well.

D $3.0\ \text{m/s}^2$ is 15 N ÷ 5.0 kg, from adding the two forces instead of subtracting.

Watch out for

D. Adding forces that oppose each other. Friction always opposes the motion, so it subtracts — then set the direction of the acceleration from the direction of the resultant, not from the larger applied force out of habit.

Q9 Answer D

Why D is correct

The model swings from side to side and finally stops, so it has settled into stable equilibrium.

In that resting position the weight of the model must produce no turning effect about the pivot. That happens only when the line of action of the weight passes through the pivot — that is, when the centre of gravity is vertically BELOW the pivot.

Drawing a vertical line down from the pivot, the only marked point it passes through is D.

Why the rest are wrong

A Off to one side of the pivot. The weight would then produce a moment about the pivot and the model would swing back, so it could not rest there.

B Directly above the pivot. That is the unstable position — the smallest disturbance would topple it, and the model has come to rest.

C At the pivot itself. That would leave the model in neutral equilibrium, resting in any position, which is not what is described.

Watch out for

A. The centre of gravity of a hooked or L-shaped object often sits outside the material, so students hunt for a point that looks "inside the bird". Use the rule instead: at rest on a pivot, draw the vertical line through the pivot and read off which labelled point lies on it.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q10 Answer **A**

Why A is correct

Stability improves when the centre of gravity is LOW and the base is WIDE. An object topples when it is tilted far enough for the line of action of its weight to fall outside its base.

The masses are equal, so the comparison is purely geometric.

A has its G marked closest to the ground of all four, and its base is at least as wide as any of the others. It therefore has to be tilted through the largest angle before the weight's line of action leaves the base.

Why the rest are wrong

B Its base is about as wide as A's, but its centre of gravity is roughly three times as high.

C Its base is slightly narrower than A's and its centre of gravity is higher.

D The least stable — the highest centre of gravity of the four, on a base no wider than the rest.

Watch out for

B. The tall triangle looks solid and its base is wide. Compare the HEIGHT of each G above the ground line first: that is what separates these four, and A's is clearly the lowest.

Q11 Answer **C**

Why C is correct

The box is a cube, so each side is the cube root of the volume: side = $\sqrt[3]{64\ \text{cm}^3} = 4.0\ \text{cm}$.

Area of one inner face = $4.0\ \text{cm} \times 4.0\ \text{cm} = 16\ \text{cm}^2$.

$F = p \times A = 25\ \text{N/cm}^2 \times 16\ \text{cm}^2 = 400\ \text{N}$.

The pressure is already given per cm^2 and the area is in cm^2, so no conversion is needed.

Why the rest are wrong

A $100\ \text{N} = 25 \times 4.0$, using the side LENGTH in place of the face area.

B $200\ \text{N} = 25 \times 8$, from taking $\sqrt{64} = 8$ as the side instead of $\sqrt[3]{64} = 4$.

D $1600\ \text{N} = 25 \times 64$, using the VOLUME in place of the area.

Watch out for

D. Multiplying the pressure straight by 64. Pressure acts on an area, so get the side length first ($\sqrt[3]{64} = 4.0\ \text{cm}$), then the area of one face.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q12 Answer **B**

Why B is correct

Pressure due to a liquid column: $p = \rho g h$. The same g applies to both, so $p \propto \rho h$.

First liquid: $\rho h = 1200\ \text{kg/m}^3 \times 10\ \text{m} = 12\,000$

Second liquid: $\rho h = 300\ \text{kg/m}^3 \times 80\ \text{m} = 24\,000$

Ratio = $24\,000 \div 12\,000 = 2$, so the second pressure is $2p$.

Sense check: the second liquid is 4 times less dense but 8 times deeper, so $8 \div 4 = 2$ times the pressure.

Why the rest are wrong

A $p/2$ has the ratio upside down.

C $4p$ comes from halving the density ratio instead of quartering it (8 × ½ rather than 8 × ¼).

D $32p$ multiplies by the density ratio (8 × 4) instead of dividing by it.

Watch out for

D. Using $1200/300 = 4$ rather than $300/1200 = \frac{1}{4}$. Write $p \propto \rho h$, put both numbers into one ratio, and sense-check the answer against the two competing changes.

Q13 Answer **C**

Why C is correct

The work done in slowing the train is equal to the kinetic energy it loses.

Initial $KE = \frac{1}{2} \times 40\,000\ \text{kg} \times (30\ \text{m/s})^2 = 1.8 \times 10^7\ \text{J}$

Final $KE = \frac{1}{2} \times 40\,000\ \text{kg} \times (25\ \text{m/s})^2 = 1.25 \times 10^7\ \text{J}$

Work done = $1.8 \times 10^7 - 1.25 \times 10^7 = 5.5 \times 10^6\ \text{J}$

Why the rest are wrong

A $1.0 \times 10^5\ \text{J} = \frac{1}{2} \times 40\,000 \times 5$, with the velocity change not squared at all.

B $5.0 \times 10^5\ \text{J} = \frac{1}{2} \times 40\,000 \times 5^2$, squaring the CHANGE in velocity.

D $1.1 \times 10^7\ \text{J} = 40\,000 \times (30^2 - 25^2)$, with the ½ left out.

Watch out for

B. $\frac{1}{2}m(u^2 - v^2)$ is not $\frac{1}{2}m(u - v)^2$. Square each velocity first, then subtract — the two give very different answers.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q14 Answer **D**

Why D is correct

Energy supplied by the motor: $E = Pt = 60\ \text{W} \times 8.0\ \text{s} = 480\ \text{J}$.

The block moves at steady speed, so it gains no kinetic energy and the bench is horizontal, so it gains no gravitational potential energy. All 480 J goes into working against friction.

Work done = $F \times d$, so $F = 480\ \text{J} \div 3.0\ \text{m} = 160\ \text{N}$.

At steady speed the pull and the friction are balanced, so the frictional force is 160 N.

Quicker route: speed = $3.0\ \text{m} \div 8.0\ \text{s} = 0.375\ \text{m/s}$, and $P = Fv$ gives $F = 60\ \text{W} \div 0.375\ \text{m/s} = 160\ \text{N}$.

Why the rest are wrong

A $2.5\ \text{N} = 60 \div (8.0 \times 3.0)$ — divided by the time and the distance, when the time should multiply.

B 16 N is 160 N with a factor of ten lost in the arithmetic.

C $20\ \text{N} = 60 \div 3.0$, using the POWER where the work done is needed.

Watch out for

C. Dividing power by distance. Power is not work — turn it into energy first $(E = Pt)$, then into force $(F = E/d)$.

Q15 Answer **D**

Why D is correct

Total running time: 8.0 h/day × 7 days/week × 4 weeks = 224 h.

In seconds: $224\ \text{h} \times 3600\ \text{s/h} = 8.064 \times 10^5\ \text{s}$.

$E = Pt = 5.0\ \text{W} \times 8.064 \times 10^5\ \text{s} = 4.0 \times 10^6\ \text{J}$.

Why the rest are wrong

A $1.1 \times 10^3\ \text{J} = 5.0 \times 224$, leaving the time in hours. The joule requires seconds.

B $6.7 \times 10^4\ \text{J} = 5.0 \times 13\,440$, from converting the hours to minutes and then treating them as seconds.

C $5.8 \times 10^5\ \text{J} = 5.0 \times 115\,200$, and 115 200 s is 32 h — that is 8.0 h × 4 DAYS, from reading "four weeks" as four days.

Watch out for

A. Leaving the time in hours. Also count the days: four weeks is 28 days, not 4.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q16 Answer **B**

Why B is correct

Air is a gas, with a density of roughly $1.2\ \mathrm{kg/m^3}$ — about a thousand times less than any common liquid or solid.

Water has a density of $1000\ \mathrm{kg/m^3}$.

Aluminium has a density of about $2700\ \mathrm{kg/m^3}$. It sinks in water, which tells you directly that it is the denser of the two.

Why the rest are wrong

A Places aluminium below water. Aluminium sinks in water, so it must be denser.

C Places air between water and aluminium.

D Places air last, as the densest of the three.

Watch out for

A. Aluminium feels light for its size compared with iron or lead, which tempts students to rank it below water. The test is whether it floats — aluminium sinks, so it is denser than water.

Q17 Answer **B**

Why B is correct

Conduction in a metal happens by two processes running together.

Lattice vibration: the hot end's ions vibrate more, and the vibration is passed on to neighbouring ions. This happens in EVERY solid, metal or not.

Free electrons: a metal has delocalised electrons that are not tied to any one ion. At the hot end they gain kinetic energy, move rapidly through the lattice, and give up that energy in collisions with ions at the cold end. Only a metal has these, and they are why metals conduct so much better than non-metals.

Why the rest are wrong

A Density changes within the material describes convection, which needs a fluid and does not occur in a solid conductor.

C Increased ionic vibration passing on to neighbours is a real conduction process — but it occurs in non-metal solids too, so it is not the one asked for.

D Ions moving through the material and colliding describes conduction in a liquid electrolyte. In a solid metal the ions stay fixed in the lattice; it is the electrons that move.

Watch out for

C. It is a genuine mechanism in a metal, just not one unique to a metal. The deciding word in the question is "only".

thelearningcave.com.sg
Physics. Math. Chemistry.

Q18 Answer **D**

Why D is correct

Water is anomalous between 0 °C and 4 °C: warming it in this range makes it contract, so it becomes denser. Its density is greatest at 4 °C.

Student 3 is correct. 3 °C is closer to the 4 °C density maximum than 1 °C is, so water at 3 °C is denser and sinks in water at 1 °C.

Student 2 is wrong. A molecule does not change size. What changes is the SPACING and arrangement of the molecules — below 4 °C they start to take up the open, ice-like arrangement, which occupies more space.

Student 1 is wrong. Convection currents can still occur between 0 °C and 4 °C. They simply run the other way round, because in this range it is the WARMER water that is denser and therefore sinks.

Why the rest are wrong

A Takes student 1 alone, whose statement is too strong.

B Includes student 2, and molecules do not expand.

C Student 2 alone, which is the clearest error of the three.

Watch out for

A. Student 1 is the tempting one, because the usual convection picture really does break down here. Normally you heat water at the bottom, it expands, becomes less dense and rises. Between 0 °C and 4 °C water does the opposite — warming it makes it contract — so water warmed at the bottom becomes DENSER and stays where it is. Students who see that far then take one step too many and conclude that nothing moves at all. It does move: the circulation simply runs the other way round, with the warmer water sinking. Test all three statements against the single rule that decides them — the denser water sinks, and water is densest at 4 °C. Note too that student 3 is beyond dispute and there is no "1 and 3" option, which settles the answer on its own.

Q19 Answer **A**

Why A is correct

Both objects have been in the refrigerator for several hours, so both have reached the same temperature — that of the refrigerator.

What you feel as "cold" is your skin losing thermal energy. The metal is a good conductor, so it carries energy away from your hand quickly and your skin cools rapidly.

Plastic is a poor conductor, so energy leaves your hand slowly and the plastic feels much less cold even though it is at the same temperature.

Why the rest are wrong

B Specific latent heat concerns a change of state. Neither object is melting or boiling.

C A lower heat capacity would mean the metal warms up more easily from your hand, making it feel LESS cold, not more.

D Both have been in the same refrigerator for hours, so they are at the same temperature.

Watch out for

D. "It feels colder, so it must be colder" is the instinctive answer. What your skin actually senses is the RATE at which it loses energy, not the temperature of the object.

Q20 Answer A

Why A is correct

The question asks which statement is NOT correct.

A thermometer measures TEMPERATURE, which is a measure of the AVERAGE kinetic energy of the particles.

Internal energy is the TOTAL energy — kinetic plus potential — of all the particles in the object, so it depends on how much material there is as well as on how hot it is.

A bathtub of warm water and a cup of the same warm water give identical thermometer readings but have very different internal energies. So statement A is false, and it is the answer.

Why the rest are wrong

B Correct. Doing work on an object — rubbing, compressing, stirring — raises its internal energy without any heating.

C Correct. That is the definition of internal energy.

D Correct. A temperature rise means a rise in the average kinetic energy of the particles.

Watch out for

Rushing past the word NOT. Read all four, confirm that three are true statements, and the false one is the answer — here, the thermometer.

Q21 Answer B

Why B is correct

Heat capacity is the energy needed to raise the temperature of the WHOLE object by 1 °C: $C = Q/\Delta\theta$.

$\Delta\theta = 35^\circ\text{C} - 25^\circ\text{C} = 10^\circ\text{C}$

$C = 9000\ \text{J} \div 10^\circ\text{C} = 900\ \text{J}/^\circ\text{C}$

The 2.0 kg is not needed here. It would be needed only for the SPECIFIC heat capacity: $c = C/m = 900 \div 2.0 = 450\ \text{J}/(\text{kg}^\circ\text{C})$.

Why the rest are wrong

A 450 J/°C is the specific heat capacity of iron, 450 J/(kg °C), with the wrong unit attached.

C $4500\ \text{J}/^\circ\text{C} = 9000 \div 2.0$, dividing by the mass instead of by the temperature rise.

D $90\,000\ \text{J}/^\circ\text{C} = 9000 \times 10$, multiplying by the temperature rise instead of dividing.

Watch out for

A. The mass is given precisely so that students who confuse the two quantities will divide by it. Heat capacity belongs to the OBJECT (J/°C); specific heat capacity belongs to the MATERIAL, per kilogram (J/(kg °C)).

thelearningcave.com.sg
Physics. Math. Chemistry.

Q22 Answer B

Why B is correct

Time in seconds: $t = 0.80\,\text{min} \times 60 = 48\,\text{s}$.

Energy supplied: $E = Pt = 50\,\text{W} \times 48\,\text{s} = 2400\,\text{J}$.

Convert the specific heat capacity: $c = 2.0\,\text{J/(g°C)} = 2000\,\text{J/(kg°C)}$.

$E = mc\Delta\theta$, so $\Delta\theta = 2400\,\text{J} \div (0.40\,\text{kg} \times 2000\,\text{J/(kg°C)}) = 2400 \div 800 = 3.0°\text{C}$.

Final temperature = $25°\text{C} + 3.0°\text{C} = 28°\text{C}$.

Why the rest are wrong

A 22 °C subtracts the 3.0 °C rise. A heater raises the temperature.

C $50°\text{C} = 2400\,\text{J} \div 48\,\text{s}$, dividing the energy by the time instead of by mc — and that result is a power, not a temperature.

D $75°\text{C} = 25 + 50$, adding the power in watts to the starting temperature.

Watch out for

The unit on c. It is given per GRAM, not per kilogram. Either convert it to 2000 J/(kg °C) or keep the mass in grams (400 g) — mixing kilograms with a per-gram value is the commonest slip in this question.

Q23 Answer C

Why C is correct

Evaporation happens only at the SURFACE, where the faster-moving molecules can escape. It happens at any temperature.

Boiling happens THROUGHOUT the liquid — bubbles of vapour form inside the body of the liquid as well as at the surface — and only at one particular temperature, the boiling point.

So the change that occurs only at the surface is evaporation, and the change that occurs only at one particular temperature is boiling. That is row C.

Why the rest are wrong

A Puts boiling in both columns; boiling is not confined to the surface.

B Has both columns the wrong way round.

D Puts evaporation in both columns; evaporation happens at all temperatures, not one.

Watch out for

A. Boiling is most visible at the surface, so students associate it with the surface. The defining feature of boiling is that bubbles form INSIDE the liquid.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q24 Answer A

Why A is correct

A wave transfers energy from one place to another through a medium.

The particles of the medium vibrate about their own fixed positions and return to them; they are not carried along with the wave. So no matter is transferred.

Why the rest are wrong

B The reverse of the truth — it is energy that travels, not matter.

C True only of a longitudinal wave. The word "always" makes it false, since transverse waves exist.

D True only of a transverse wave, and "always" makes it false for the same reason.

Watch out for

C and D. Each is a correct description of one type of wave. The word "always" is what breaks them — the question asks for a statement true of wave motion in general.

Q25 Answer D

Why D is correct

Neighbouring crests are one wavelength apart. P lies on the innermost crest and Q on the outermost, with two crests drawn between them — so P to Q spans three wavelengths, not four.

$\lambda = 12\ \text{cm} \div 3 = 4.0\ \text{cm}$

The crests travel a distance equal to eight wavelengths in 4.0 s, so eight complete waves pass a point in 4.0 s.

$f = 8 \div 4.0\ \text{s} = 2.0\ \text{Hz}$

Check with $v = f\lambda$: $v = 2.0\ \text{Hz} \times 4.0\ \text{cm} = 8.0\ \text{cm/s}$, and eight wavelengths is $8 \times 4.0 = 32\ \text{cm}$ in 4.0 s, which is also 8.0 cm/s.

Why the rest are wrong

A Both numbers wrong: $\lambda = 3.0\ \text{cm}$ from counting four wavelengths between P and Q, and $f = 0.50\ \text{Hz}$ from dividing the time by the number of waves.

B Frequency is right, but $\lambda = 3.0\ \text{cm}$ comes from counting the four crests instead of the three spaces between them.

C Wavelength is right, but $f = 0.50\ \text{Hz}$ is 4.0 s ÷ 8 — that is the period of each wave, not the frequency.

Watch out for

Counting circles instead of gaps. Four crests give three wavelengths between the first and the last, in the same way that four fence posts have three gaps between them.

Q26 Answer B

Why B is correct

At total internal reflection the angle of reflection equals the angle of incidence. The diagram marks 55° between the normal and the reflected ray, so the angle of incidence is 55° as well.

The ray arrives travelling down-and-to-the-right and leaves travelling up-and-to-the-right. The angle its DIRECTION turns through is

$180^\circ - (55^\circ + 55^\circ) = 70^\circ$

Same result the short way: each ray makes $90^\circ - 55^\circ = 35^\circ$ with the surface, and the direction swings through $2 \times 35^\circ = 70^\circ$.

Why the rest are wrong

A 35° is the angle between one ray and the surface, not the change in direction.

C 110° is the angle BETWEEN the two ray lines as drawn (the V opening upwards), which is not the same as the angle the direction turns through.

D $125^\circ = 180^\circ - 55^\circ$, using only one of the two equal angles.

Watch out for

C. The angle between the incident and reflected rays (110°) is not the angle the ray's direction CHANGES by. The two are related by: deviation = 180° − angle between the rays.

Q27 Answer D

Why D is correct

Statement 1 is wrong. The speed of light in a medium is $v = c/n = 3.0 \times 10^8 \div 1.5 = 2.0 \times 10^8\ \mathrm{m/s}$. A refractive index of 1.5 means exactly this: light travels 1.5 times slower inside the fibre than in a vacuum.

Statement 2 is correct. Optical fibre loses much less signal over a given distance than copper cable, which is a principal reason it is used for long-distance communication.

So statement 2 only.

Why the rest are wrong

A Rejects statement 2, which is a genuine advantage of optical fibre.

B Accepts statement 1; $3.0 \times 10^8\ \mathrm{m/s}$ is the speed in a vacuum, not inside glass.

C Accepts statement 1 and rejects statement 2 — both the wrong way round.

Watch out for

C. $3.0 \times 10^8\ \mathrm{m/s}$ is such a familiar number that students accept it without asking "in what medium?". Any refractive index greater than 1 means light travels slower than $3.0 \times 10^8\ \mathrm{m/s}$ in that material.

THE LEARNING CAVE thelearningcave.com.sg Physics. Math. Chemistry.

Q28 Answer **B**

Why B is correct

For a converging lens of focal length $f = 16\ \text{cm}$ (so $2f = 32\ \text{cm}$):

u greater than $2f$ (more than 32 cm) — image real, inverted, DIMINISHED

$u = 2f (32\ \text{cm})$ — image real, inverted, SAME SIZE

u between f and $2f (16\ \text{cm}$ to 32 cm) — image real, inverted, MAGNIFIED

u less than f (under 16 cm) — image VIRTUAL, upright, magnified

Only 20 cm lies between 16 cm and 32 cm, so B is the only object distance giving a real, magnified image.

Why the rest are wrong

A 12 cm is inside the focal length, so the image is virtual — magnified, but not real.

C 32 cm is exactly $2f$, so the image is real but the same size as the object.

D 40 cm is beyond $2f$, so the image is real but diminished.

Watch out for

A. It does give a magnified image, so students who check only that word choose it. Both conditions must hold — real AND magnified — and anything inside the focal length gives a virtual image.

Q29 Answer **B**

Why B is correct

Microwaves are used for communication with satellites. They pass through the atmosphere and the ionosphere with little absorption, so the signal reaches orbit and comes back.

Their short wavelength also lets a dish aerial send them as a narrow beam, which is what is needed to aim at a single satellite.

Why the rest are wrong

A Infrared is used for optical fibres and remote controls, but it is strongly absorbed by water vapour in the atmosphere.

C Visible light is scattered and blocked by cloud, so it is not reliable for a ground-to-orbit link.

D X-rays are ionising and are absorbed high in the atmosphere; they are used for medical imaging and security scanning.

Watch out for

A. Infrared is also a communication wave, so it looks plausible. The cue is the word "satellites" — the signal has to cross the whole atmosphere, and microwaves are the part of the spectrum that gets through.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q30 Answer C

Why C is correct

Sound travels faster in water, so the sound that arrives FIRST is the one that came through the water. That first arrival is the 0.50 s given.

Distance: $d = vt = 1500\ \text{m/s} \times 0.50\ \text{s} = 750\ \text{m}$.

Time for the same distance through air: $t = d/v = 750\ \text{m} \div 340\ \text{m/s} = 2.21\ \text{s}$.

The question asks how long AFTER the first sound the second arrives: $2.21\ \text{s} - 0.50\ \text{s} = 1.7\ \text{s}$.

Why the rest are wrong

A $0.11\ \text{s} = 0.50 \times 340/1500$, the speed ratio applied upside down.

B $0.61\ \text{s} = 0.50 + 0.11$, that same wrong interval added to the first arrival time.

D 2.2 s is the total time through air, measured from when the sound was EMITTED — the 0.50 s already elapsed has not been subtracted.

Watch out for

D. The question asks how long after FIRST HEARING the sound, not how long after it was emitted. The last step is a subtraction.

Q31 Answer B

Why B is correct

Read the charges: P carries + charges, Q and S both carry − charges.

P and Q are unlike, so they ATTRACT. Q and S are like, so they REPEL. That alone rules out C and D, which have the two interactions the wrong way round.

The strength of an electrostatic force depends on the separation — the closer the charges, the stronger the force.

In the diagram Q and S hang close together, while P hangs far away on the other side. So the repulsion between Q and S is the stronger force, which is the same as saying the attraction between P and Q is WEAKER.

Why the rest are wrong

A Has the two kinds of force right but the comparison backwards — it makes the widely separated pair exert the stronger force.

C Describes P–Q as repulsion. P is positive and Q is negative, so they attract.

D Describes P–Q as repulsion and Q–S as attraction — both contradict the signs drawn.

Watch out for

A. Students settle the attract-or-repel part correctly and then stop reading. The comparison is decided by the SEPARATIONS in the diagram, so measure the gaps before choosing.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q32 Answer **A**

Why A is correct

Electric field lines show the direction of the force on a small POSITIVE test charge. They begin on positive charges and end on negative charges.

In this diagram every arrowhead points INWARDS — towards X and towards Y. Field lines therefore end on both, so both charges are negative.

The shape confirms that the two charges are alike: the lines curve away from the region between X and Y and no line runs directly from one to the other. Two unlike charges would show lines crossing the gap from the positive one to the negative one.

Why the rest are wrong

B Makes the charges unlike. Field lines would then run straight across the gap from Y to X.

C Also makes them unlike, with the same problem.

D Gives the same like-charge pattern, but with both positive every arrow would point OUTWARDS.

Watch out for

D. The overall shape of the pattern fits D just as well as A — only the ARROWHEADS separate them. Check the direction of the arrows before anything else.

Q33 Answer **D**

Why D is correct

Copper is a conductor, so the sphere contains free electrons that can move within it.

The negatively charged rod is brought near the left-hand side. Like charges repel, so the free electrons are pushed to the far (right-hand) side of the sphere.

The right-hand side therefore becomes more negative, and the left-hand side, having lost electrons, is left positively charged.

The sphere stands on an INSULATING mat and is not touched, so no charge can enter or leave it. Its total charge must still be the same net negative charge it started with.

D is the only diagram with all three features: positive on the near side, negative on the far side, and a net negative total (six − against three +, matching the three − marked on the sphere at the start).

Why the rest are wrong

A Shows the negative charge driven to the far side, which is the right physics, but shows no induced positive charge on the near side and doubles the amount of negative charge on the sphere.

B Equal numbers of + and −, so the sphere has become neutral. Nothing has been added or removed, so its net charge cannot change.

C Has the induced charges the wrong way round. A negative rod repels electrons AWAY from itself, so the near side cannot be the negative side.

Watch out for

A. It gets the key idea right — the electrons move to the far side — so it is the tempting choice. Two checks separate it from D: the near side must end up POSITIVE, because that is where the electrons left from; and the net charge on the sphere must be unchanged, which A does not show.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q34 Answer **D**

Why D is correct

Charge: $t = 4.0\,\text{min} = 240\,\text{s}$, so $Q = It = 2.0\,\text{A} \times 240\,\text{s} = 480\,\text{C}$.

Direction: on a cell symbol the LONG plate is the positive terminal. Here the long plate is on the left.

Conventional current leaves the positive terminal, runs down the left-hand side through P, along the bottom through the lamp, up the right-hand side and back through the switch to the negative terminal — that is anticlockwise.

Electrons are negative, so they drift in the OPPOSITE direction to the conventional current: clockwise.

Why the rest are wrong

A Both parts wrong: 8.0 C uses $t = 4.0$ without converting minutes to seconds, and anticlockwise is the conventional current direction.

B Direction right, but 8.0 C again leaves the time in minutes.

C Charge right, but anticlockwise is the direction of conventional current, not of electrons.

Watch out for

Two traps in one question. Convert 4.0 min to 240 s, and remember that electron flow is opposite to conventional current. Find the long plate of the cell first, work out the conventional current, then reverse it.

Q35 Answer **D**

Why D is correct

The potential difference across a component is the work done in driving UNIT charge through it: $V = W/Q$.

Its unit, the volt, is one joule per coulomb.

Why the rest are wrong

A Charge passing per unit time is the definition of CURRENT, not potential difference.

B Ohm's law is $V = IR$ — current MULTIPLIED by resistance, not divided by it.

C Almost right, but it says "an electron" instead of unit charge. Potential difference is per coulomb; one electron carries $1.6 \times 10^{-19}\,\text{C}$, so this would give a number 10^{19} times too small.

Watch out for

C. It differs from the correct answer by only two words. Potential difference is always a per-unit-charge quantity — per coulomb, never per electron.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q36 Answer **A**

Why A is correct

Trace the circuit. The battery feeds the TOP end of the rheostat. The bottom end Y and the far side of the lamp both return to the same bottom node.

The slider sits at X, dividing the rheostat into two parts. The section XY is 6.0Ω, so the section from the top end down to X is $20\Omega - 6.0\Omega = 14\Omega$.

All the circuit current must pass through that 14Ω section.

From X there are two routes back to the bottom node: through the remaining 6.0Ω of the rheostat (X to Y), or through the 6.0Ω lamp. These two are in PARALLEL.

$1/R = 1/6.0 + 1/6.0$, so $R = 3.0\Omega$

Total resistance = $14\Omega + 3.0\Omega = 17\Omega$

Why the rest are wrong

B $23\Omega = 20 + 3.0$, using the whole rheostat in series with the parallel pair and so counting the XY section twice.

C $26\Omega = 20 + 6.0$, treating the rheostat as a single 20Ω resistor in series with the lamp.

D $32\Omega = 20 + 6.0 + 6.0$, adding everything in series.

Watch out for

C. Treating the rheostat as one 20Ω resistor. The slider splits it into two parts that do different jobs: the part above X carries the whole current, and the part below X is in parallel with the lamp.

Q37 Answer **A**

Why A is correct

Resistance of a uniform wire: $R = \rho L/A$, with $A = \pi r^2$.

Doubling the radius multiplies the cross-sectional area by $2^2 = 4$, which DIVIDES the resistance by 4.

Doubling the length MULTIPLIES the resistance by 2.

$R_{\text{Q}} = 80\Omega \times 2 \div 4 = 40\Omega$

Why the rest are wrong

B 80Ω assumes the two changes cancel. They would only cancel if resistance depended on the radius itself rather than on the area.

C 160Ω uses the doubled length and ignores the thicker wire.

D 640Ω multiplies by 4 for the radius instead of dividing by it.

Watch out for

B. "Twice as long and twice as thick, so it cancels" is the intuitive answer. Area scales as r^2, so doubling the radius cuts the resistance by four, not by two.

THE LEARNING CAVE
thelearningcave.com.sg
Physics. Math. Chemistry.

Q38 Answer **D**

Why D is correct

R_1 and R_2 are in parallel with each other. That combination is in series with R_3, and X lies on the single wire between them.

Current at X: the two parallel branches have already rejoined before X, so the whole circuit current passes through it — the same current the ammeter reads, 0.30 A.

p.d. across R_3: components in parallel have the same p.d. across them, so the p.d. across the R_1/R_2 combination equals the 2.0 V given for R_1.

The p.d.s across components in series add to the supply voltage: $V_3 = 6.0\ \text{V} - 2.0\ \text{V} = 4.0\ \text{V}$.

Why the rest are wrong

A Both parts wrong: 0.10 A comes from splitting the current at X, and 2.0 V copies the p.d. across R_1.

B p.d. right, but 0.10 A treats X as if it were inside one of the parallel branches.

C Current right, but 2.0 V puts R_3 in parallel with R_1 rather than in series with the pair.

Watch out for

A. Splitting the current at X. Follow the wire with your finger: the branches rejoin before X, so the full 0.30 A flows there.

Q39 Answer **C**

Why C is correct

The switch must be placed in the LIVE wire, between the live pin and the heating element.

With the switch off, the element is then cut off from the live supply and sits at the same potential as earth, so it is safe to touch.

Why the rest are wrong

A Puts the switch in the earth wire. The earth wire carries no current in normal use, so the switch would not turn the heater off at all — and it would break the earthing that protects the user.

B Also in the earth wire, and it does not even connect to the element.

D Switching the neutral does stop the heater working, but the element stays connected to the live pin at mains potential. Anyone touching it could receive a shock even with the switch off.

Watch out for

D. It switches the heater off, so it looks acceptable. The reason it fails is safety, not function: switching the neutral leaves the element live.

thelearningcave.com.sg
Physics. Math. Chemistry.

Q40 Answer **A**

Why A is correct

Turns: $N_s/N_p = V_s/V_p$

$N_s = 1000 \times (120\,000\ \text{V} \div 3000\ \text{V}) = 1000 \times 40 = 40\,000$ turns

Current: the transformer is 100% efficient, so the output power equals the input power.

$V_p I_p = V_s$ Is $\rightarrow 3000\ \text{V} \times 8.0\ \text{A} = 24\,000\ \text{W}$

$I_s = 24\,000\ \text{W} \div 120\,000\ \text{V} = 0.20\ \text{A}$

Sense check: this is a step-up transformer with a ratio of 40, so the current must come DOWN by 40: $8.0 \div 40 = 0.20\ \text{A}$.

Why the rest are wrong

B Turns right, but $320\ \text{A} = 8.0 \times 40$ steps the current UP alongside the voltage. That would make the output power 1600 times the input.

C Current right, but 360 000 turns comes from combining the voltages the wrong way round.

D Both parts wrong, for the two reasons above.

Watch out for

B. Stepping both the voltage and the current up. A transformer transfers power, not current — if the voltage rises by a factor, the current must fall by that same factor.

thelearningcave.com.sg
Physics. Math. Chemistry.