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TEN-YEAR SERIES · ANSWERS AND WORKED SOLUTIONS

2020 A-Level H1 Physics Paper 1

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ANSWER KEY

1 **B**	2 **C**	3 **B**	4 **C**	5 **B**	6 **B**	7 **A**	8 **B**	9 **A**	10 **D**
11 **B**	12 **C**	13 **B**	14 **C**	15 **D**	16 **D**	17 **A**	18 **C**	19 **B**	20 **B**
21 **A**	22 **B**	23 **B**	24 **B**	25 **B**	26 **C**	27 **D**	28 **C**	29 **B**	30 **C**

WORKED SOLUTIONS

Q1 Answer B

Convert to SI units:

$$c = 3 \times 10^5 \text{ km s}^{-1} = 3 \times 10^8 \text{ m s}^{-1}, \qquad d = 3 \times 10^{-1}\ \mu m = 3 \times 10^{-7} \text{ m}$$

$$t = \frac{d}{c} = \frac{3 \times 10^{-7}}{3 \times 10^8} = 1 \times 10^{-15} \text{ s}$$

Since 1 ps $= 10^{-12}$ s,

$$t = 1 \times 10^{-3} \text{ ps}$$

Q2 Answer C

$R = V/I$, so the fractional uncertainties add:

$$\frac{\Delta R}{R} = \frac{\Delta V}{V} + \frac{\Delta I}{I} = \frac{0.06}{2.00} + \frac{0.05}{2.50} = 0.03 + 0.02 = 0.05$$

$$\Delta R = (0.05)(0.800) = 0.04\ \Omega$$

Q3 Answer B

p and q are proportional, so the true line passes through the origin.

- Systematic error shifts every reading by the same amount, so the best-fit line does not pass through the origin. A large intercept means a large systematic error.
- Random error scatters the points about the line. Large scatter means a large random error.

A: through the origin, little scatter. C: intercept, little scatter. D: through the origin, large scatter. B has both an intercept and large scatter.

Q4 Answer C

The graph rises, then falls, then rises again.

- Distance travelled can never decrease, so it cannot be this graph.
- Displacement can decrease, if the teacher walks back towards the start.
- Speed can decrease, if the teacher slows down.
- Velocity can decrease, if the teacher slows down (or turns round).

Three of the four quantities could be represented.

Q5 Answer **B**

The area under a velocity–time graph gives the displacement.

From 0 to 2.0 s the stone moves upwards:

$$s_1 = \frac{1}{2}(2.0)(20) = 20 \text{ m}$$

From 2.0 s to 3.0 s it moves downwards:

$$s_2 = \frac{1}{2}(1.0)(10) = 5 \text{ m}$$

$$\text{distance} = 20 + 5 = 25 \text{ m}, \qquad \text{displacement} = 20 - 5 = 15 \text{ m}$$

Q6 Answer **B**

Horizontally there is no force, so the velocity is constant and $x \propto t$. In time $2t$ the horizontal distance is $2x$.

Vertically the ball starts with zero vertical velocity and accelerates at g, so $y = \frac{1}{2}gt^2$ and $y \propto t^2$. In time $2t$ the vertical distance is $2^2y = 4y$.

Q7 Answer **A**

Treat the two masses and the cord as one system moving in the direction of the arrows. The driving force is the difference in the weights, and friction opposes the motion:

$$F_{net} = (8.0 - 2.0)(9.81) - 3.0 = 58.9 - 3.0 = 55.9 \text{ N}$$

$$a = \frac{F_{net}}{m_{\text{total}}} = \frac{55.9}{10.0} = 5.6 \text{ m s}^{-2}$$

Q8 Answer **B**

By Newton's second law, the force on the water equals its rate of change of momentum. The water is stopped by the wall, so the force on the water equals the momentum stopped per unit time. By Newton's third law, the water exerts an equal force on the wall.

Q9 Answer **A**

The disc is uniform and pivoted at its centre, so its own weight has no moment. Only the two masses need to be considered.

The perpendicular distance from the pivot to the line of action of the weight of the 2.50 kg mass is the horizontal distance:

$$d = 0.70 \cos 60^\circ = 0.35 \text{ m}$$

The mass at X is 0.70 m horizontally from the pivot. Taking moments about the pivot:

$$mg(0.70) = (2.50)g(0.35) \quad \Rightarrow \quad m = 1.25 \text{ kg}$$

Q10 Answer **D**

The engine has to accelerate both the lorry and the trailer (no resistive forces are given):

$$F = (3000 + 1000)(2.0) = 8000 \text{ N}$$

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Q11 Answer **B**

Check each diagram for resultant force and resultant torque about the centre.

- A: forces $F + 2F - 3F = 0$, so no resultant force. Torques: F at the top and $2F$ at the bottom turn in opposite senses, leaving Fr. Torque only.
- B: the upward F and the outward F do not cancel the horizontal F, so there is a resultant force. The upward force at the left edge and the horizontal force at the top both turn the disc clockwise, and the force through the centre has no moment. Resultant torque $2Fr$. Both.
- C: the horizontal components ($-F\sin 30° + F - F\sin 30°$) and the vertical components ($F\cos 30° - F\cos 30°$) both add to zero, so there is no resultant force. Torque only.
- D: the two forces of F give equal and opposite torques, so there is no resultant torque. There is a resultant force of $2F$ to the left. Force only.

Q12 Answer **C**

The object and the capsule are both in free fall around the Earth with the same acceleration, so the object appears to float. The only force acting on the object is its weight. The weight is the centripetal force: it is not an extra force, and it is not balanced by another force.

Q13 Answer **B**

The man moves at constant velocity, so the resultant force on him is zero. The three forces W, T and P must form a closed triangle with the arrows following each other head to tail.

T acts down towards the boat and W acts down, so P must point up and to the left (backwards) to close the triangle.

In B, T is followed by W, and P returns from the end of W to the start of T: a closed triangle with arrows head to tail. In A and D two arrows start from the same point, and in C P and T start from the same point, so none of these is a closed triangle of forces in equilibrium.

Q14 Answer **C**

Work done is the area under the power–time graph.

From 10 s to 30 s the power rises steadily from 20 W to 40 W. The area is a trapezium:

$$W = \frac{1}{2}(20 + 40)(30 - 10) = 600 \text{ J}$$

Q15 Answer **D**

As the cord stretches to its maximum extension, the man is still falling but slowing down.

- He slows down, so he loses kinetic energy.
- He moves downwards, so he loses gravitational potential energy.
- The cord stretches, so it gains elastic potential energy.

Q16 Answer **D**

$$a = \frac{\Delta v}{\Delta t} = \frac{24}{10} = 2.4 \text{ m s}^{-2}$$

The engine force must provide the acceleration and balance the component of the weight down the slope:

$$F = ma + mg\sin 10° = (1000)(2.4) + (1000)(9.81)\sin 10° = 2400 + 1700 = 4100 \text{ N}$$

$$P = Fv = (4100)(24) = 9.8 \times 10^4 \text{ W} = 98 \text{ kW}$$

Q17 Answer **A**

An angle in radians is arc length divided by radius:

$$\theta = \frac{s}{r}$$

Q18 Answer **C**

When the string is vertical, the bob is at the bottom of its circular arc. The centre of the circle is above it. The resultant upward force provides the centripetal force:

$$T - W = \frac{mv^2}{r}$$

Q19 Answer **B**

$$P = I^2R \quad \Rightarrow \quad I = \sqrt{\frac{P}{R}} = \sqrt{\frac{0.25}{1000}} = 0.0158 \text{ A}$$

Each electron carries charge e, so the number passing per second is

$$\frac{I}{e} = \frac{0.0158}{1.60 \times 10^{-19}} = 9.9 \times 10^{16} \text{ s}^{-1}$$

Q20 Answer **B**

With one battery:

$$I_1 = \frac{6.0}{11 + 1.0} = 0.50 \text{ A}$$

The second battery doubles the e.m.f. but also adds another 1.0 Ω of internal resistance:

$$I_2 = \frac{12.0}{11 + 2.0} = 0.92 \text{ A}$$

$$\frac{I_2}{I_1} = 1.85$$

The current increases by a factor less than 2.

Q21 Answer **A**

$R = \rho l / A$ and both resistors are made of carbon, so $R \propto l/A$.

$$\frac{R_\text{P}}{R_\text{Q}} = \frac{3}{1/2} = 6 \quad \Rightarrow \quad R_\text{P} = 6R_\text{Q}$$

$$R_\text{P} + R_\text{Q} = 7R_\text{Q} = 84.0 \quad \Rightarrow \quad R_\text{Q} = 12.0\,\Omega$$

Q22 Answer **B**

The e.m.f. is a property of the cell and does not depend on the external circuit, so it remains constant. As the external resistance increases, the current I decreases, so the lost volts Ir decrease. The terminal p.d. $E - Ir$ increases, so C and D are both wrong.

Q23 Answer **B**

Let each resistance be R.

- A: R
- B: R in parallel with $2R$: $\frac{(R)(2R)}{3R} = 0.67R$
- C: $R + \frac{R}{2} + R = 2.5R$
- D: $2R$ in parallel with $2R$: R

B has the smallest resistance.

Q24 Answer **B**

The current flows along the 10 m length. The cross-section is a semicircle of radius 0.50 m:

$$A = \frac{1}{2}\pi r^2 = \frac{1}{2}\pi(0.50)^2 = 0.393\ \text{m}^2$$

$$R = \frac{\rho l}{A} = \frac{(4.9 \times 10^{-8})(10)}{0.393} = 1.2 \times 10^{-6}\ \Omega$$

Q25 Answer **B**

By Newton's third law, the force of Y on X is equal in size and opposite in direction to the force of X on Y, whatever the two currents are. X pulls Y with 4 N to the left, so Y pulls X with 4 N to the right. (The currents are in the same direction, so the wires attract.)

Q26 Answer **C**

The field lines lie in the plane of the paper, and the particle is deflected within the plane of the paper, in the direction of the field lines.

- A magnetic force is always perpendicular to the field. With the field lines in the plane of the paper, a magnetic force on a particle moving in the paper would be into or out of the paper. It could not curve the path within the paper.
- An electric force acts along the field lines. A positive charge is pushed in the direction of the field, which is downwards here, matching the path.

So the particle is positive and the field is electric. (Strictly, the path in a uniform electric field is a parabola. The diagram labels the curve as circular.)

Q27 Answer **D**

The magnetic force on a current is zero where the current is parallel or antiparallel to the field, and largest where it is perpendicular.

- At A (top) the current flows to the right, parallel to the field: no force.
- At C (bottom) the current flows to the left, antiparallel to the field: no force.
- At B (right side) the current flows downwards. Fleming's left-hand rule (field to the right, current down) gives a force out of the paper.
- At D (left side) the current flows upwards, giving a force into the paper.

Q28 Answer **C**

Most α-particles pass straight through, and only a very few are deflected through large angles. This is direct evidence that the positive charge and most of the mass are concentrated in a nucleus that is much smaller than the atom.

The other statements are true, but they are not deduced from this experiment.

Q29 Answer **B**

The atom contains 39 protons, $89 - 39 = 50$ neutrons and 39 electrons.

$$m = 39(1.00728) + 50(1.00867) + 39(0.00055)$$

$$m = 39.2839 + 50.4335 + 0.0215 = 89.739\ \text{u}$$

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Q30 Answer **C**

In β^- emission a neutron in the nucleus changes into a proton, and an electron is emitted. The neutron number decreases by 1 and the proton number increases by 1, so the total number of nucleons stays the same. (The mass of the nucleus decreases slightly, because energy is released.)

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