© The Learning Cave

TEN-YEAR SERIES · ANSWERS AND WORKED SOLUTIONS

2019 A-Level H1 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 **B**	2 **D**	3 **A**	4 **A**	5 **C**	6 **D**	7 **A**	8 **B**	9 **C**	10 **C**
11 **A**	12 **A**	13 **D**	14 **C**	15 **A**	16 **C**	17 **A**	18 **C**	19 **C**	20 **D**
21 **B**	22 **D**	23 **A**	24 **A**	25 **C**	26 **B**	27 **D**	28 **C**	29 **A**	30 **C**

WORKED SOLUTIONS

Q1 Answer B

Estimate the mass and the speed:

- mass of a car: about 1000 kg
- top speed on an expressway: about 90 km h^{-1}, which is 25 m s^{-1}

The car comes to rest, so the change of momentum equals its initial momentum:

$$\Delta p \approx (1000)(25) = 2.5 \times 10^4 \ \text{kg m s}^{-1}$$

The closest option is 2×10^4 kg m s^{-1}.

Q2 Answer D

$$V = \frac{\pi d^2 L}{4}$$

The diameter is squared, so its percentage uncertainty counts twice:

$$\frac{\Delta V}{V} = 2\frac{\Delta d}{d} + \frac{\Delta L}{L} = 2(2\%) + 1\% = 5\%$$

Q3 Answer A

The acceleration at 15 s is the gradient of the tangent to the curve at 15 s (not the average acceleration from the start).

Draw the tangent at $t = 15$ s, where $v \approx 17.5$ m s^{-1}. It passes through about (5 s, 12 m s^{-1}) and (25 s, 23 m s^{-1}):

$$a = \frac{23 - 12}{25 - 5} \approx 0.56 \ \text{m s}^{-2}$$

Option D (1.20 m s^{-2}) is close to $17.5/15$, the average acceleration over the first 15 s, which is not what is asked.

Q4 Answer A

The area between a velocity–time graph and the time axis is the distance travelled.

The ball falls from rest, so its speed increases steadily (the straight rising line) until it first touches the floor at the peak. The distance fallen up to that instant is the area under the rising line, which is area P.

Area Q belongs to the short time when the ball is in contact with the floor and its velocity is reversing.

Q5 Answer **C**

$$F_{net} = 63000 - 8000 = 55000 \text{ N}$$
$$a = \frac{F_{net}}{m} = \frac{55000}{40000} = 1.4 \text{ m s}^{-2}$$

Q6 Answer **D**

The two forces act on the same object and cancel, so there is no resultant force. By Newton's first law, the object keeps moving with constant velocity. The first law is used.

Newton's third law describes a pair of forces that two bodies exert on each other, acting on different bodies. These two forces both act on the same object, so they are not a third-law pair. The third law is not used.

Q7 Answer **A**

Impulse is force $\times$ time for which it acts, $F\Delta t$, which equals the change in momentum.

- B: the rate of change of kinetic energy is power, not impulse.
- C: force $\div$ time is not momentum. Momentum is mass $\times$ velocity.
- D: the rate of change of velocity is acceleration.

Q8 Answer **B**

While coupled, the whole train (mass 2.0×10^5 kg) accelerates at

$$a = \frac{1.2 \times 10^5}{2.0 \times 10^5} = 0.60 \text{ m s}^{-2}$$

After 20 s both carriages are moving at $v = (0.60)(20) = 12$ m s^{-1}.

After the coupling breaks:

- the rear carriage has no force on it, so it continues at 12 m s^{-1}
- the front carriage has the full traction force on half the mass, so $a = 1.2 \times 10^5 / 1.0 \times 10^5 = 1.2$ m s^{-2}

Relative to the rear carriage, the front carriage starts from rest and accelerates at 1.2 m s^{-2}:

$$\Delta s = \frac{1}{2}(1.2)(20)^2 = 240 \text{ m}$$

Q9 Answer **C**

The impulse on a body equals its change in momentum.

The slider of mass m starts at rest and moves off at v, so

$$\text{impulse} = mv - 0 = mv$$

Q10 Answer **C**

The string must be attached at the centre of gravity of the rod and load together. Take distances from the left-hand end (0).

At first, the load $2.0W$ is at $0.2x$ and the rod's weight W acts at its midpoint, $0.5x$:

$$d_1 = \frac{(2.0W)(0.2x) + W(0.5x)}{3.0W} = \frac{0.9x}{3.0} = 0.3x$$

With the load moved to $0.8x$:

$$d_2 = \frac{(2.0W)(0.8x) + W(0.5x)}{3.0W} = \frac{2.1x}{3.0} = 0.7x$$

The string must move $0.7x - 0.3x = 0.4x$.

Q11 Answer **A**

Resultant force: in the vector diagram, X, Y and Z are drawn tip to tail, starting at the lower dot. The chain ends at the upper dot, directly north of the starting point. The resultant force is the arrow from the start to the end of the chain, so it points north.

Moments about P:

- Z: its line of action passes through P, so it has no moment.
- Y: it acts towards the east along a line north of P, so it gives a clockwise moment.
- X: it acts towards the north-west from a point just south-east of P. Its line of action passes to the west of P, so it also gives a clockwise moment.

The resultant moment about P is clockwise.

Q12 Answer **A**

Consider the forces on point Y: the weight W (down), the tension T in the cord (horizontal, towards the wall) and the push C of the rod (along the rod, away from X). The rod makes 50° with the vertical.

Vertically:

$$C\cos 50^\circ = W \quad \Rightarrow \quad C = \frac{W}{\cos 50^\circ} = 1.56W$$

Horizontally:

$$T = C\sin 50^\circ = W\tan 50^\circ = 1.19W$$

Both are greater than W.

Q13 Answer **D**

The force of gravity on the ball is its weight mg, which is constant. The work done by gravity is

$$W = mgd$$

W is proportional to d: a straight line through the origin.

Q14 Answer **C**

With a constant force, the acceleration is constant. From rest, $v = at$, so $v \propto t$.

$$E_\text{k} = \frac{1}{2}mv^2 \propto t^2$$

At $3t$ the speed is 3 times as large, so the kinetic energy is $3^2 = 9$ times as large: $9E$.

Q15 Answer **A**

The mass loses potential energy as it moves from P to Q, so the gravitational force on it acts from P towards Q: to the right.

The work done by gravity equals the loss of potential energy:

$$mgx = E \quad \Rightarrow \quad g = \frac{E}{mx}$$

Q16 Answer **C**

- Gaining kinetic energy: the mass is speeding up, so it is moving towards line 2, where its speed is greatest.
- Gaining gravitational potential energy: the mass is moving upwards.
- Spring losing elastic potential energy: as the mass rises, the extension of the spring decreases.

So the mass must be below line 2 and moving upwards. Only C is below line 2 with an upward arrow. (D is moving upwards above line 2, where it is slowing down.)

Q17 Answer **A**

The useful output power is 20% of the input:

$$P_{out} = (0.20)(9.6) = 1.92 \text{ W}$$

At steady speed, the useful power raises the mass: $P = Fv = mgv$.

$$v = \frac{1.92}{(0.50)(9.81)} = 0.39 \text{ m s}^{-1}$$

Q18 Answer **C**

The stone is moving in a circle, so it has a centripetal acceleration, even though its speed is constant.

$$a = \frac{v^2}{r} = \frac{(1.4)^2}{0.40} = 4.9 \text{ m s}^{-2}$$

Q19 Answer **C**

$$\omega = 2\pi f = 2\pi(3.0) = 18.8 \text{ rad s}^{-1}$$
$$F = m\omega^2 r = (0.50)(18.8)^2(0.20) = 36 \text{ N}$$

Q20 Answer **D**

The centripetal force is the resultant force on S, and it always points towards the centre of the circle, P. (It is provided by the gravitational pull of the planet.)

By Newton's second law, the acceleration is in the same direction as the resultant force: towards P.

Q21 Answer **B**

The two resistors are in parallel, so they have the same p.d., equal to the p.d. across XY. The largest p.d. that keeps the power in each 100 Ω resistor at 4.0 W is

$$P = \frac{V^2}{R} \quad \Rightarrow \quad V = \sqrt{PR} = \sqrt{(4.0)(100)} = 20 \text{ V}$$

Q22 Answer **D**

The arrangement is one resistor in series with two resistors in parallel.

Maximum: put the largest resistor (3 Ω) in series.

$$R = 3 + \frac{(1)(2)}{1+2} = 3 + 0.67 = 3.67\,\Omega$$

This is between 3 Ω and 4 Ω.

Minimum: put the smallest resistor (1 Ω) in series.

$$R = 1 + \frac{(2)(3)}{2+3} = 1 + 1.2 = 2.2\,\Omega$$

This is between 2 Ω and 3 Ω.

Q23 Answer **A**

By symmetry, the top and bottom junctions in the middle are at the same potential (each is halfway along a path of two equal resistors from X to Y). There is no p.d. across the middle resistor, so no current flows in it and it can be removed.

That leaves two paths of $2R$ in parallel:

$$R_{XY} = \frac{(2R)(2R)}{2R + 2R} = R$$

Q24 Answer **A**

Voltmeter: it is across the 200 Ω resistor, which carries the full 3.2 mA.

$$V = IR = (3.2 \times 10^{-3})(200) = 0.64 \text{ V}$$

Ammeter: the 3.2 mA divides between the 600 Ω and 200 Ω branches. They have the same p.d., so the current divides in the inverse ratio of the resistances, 1 : 3.

$$I_{600} = \frac{200}{600 + 200}(3.2) = 0.80 \text{ mA}$$

Q25 Answer **C**

Let each resistance be R. The network is C in parallel with an upper path, which is (A in parallel with B and the unlabelled resistor in series) followed by D.

With all resistors in place:

$$R_{\text{upper}} = \frac{(R)(2R)}{3R} + R = \frac{5R}{3}, \qquad R_{\text{total}} = \frac{(5R/3)(R)}{5R/3 + R} = 0.63R$$

Remove each resistor in turn:

- A removed: upper path $= 2R + R = 3R$, total $= \frac{(3R)(R)}{4R} = 0.75R$
- B removed: upper path $= R + R = 2R$, total $= \frac{(2R)(R)}{3R} = 0.67R$
- C removed: only the upper path is left, total $= 1.67R$
- D removed: the upper path is broken, only C is left, total $= R$

Removing C gives the greatest increase.

Q26 Answer **B**

An extra component in parallel increases the ammeter reading only if it carries current.

- 40 Ω resistor: it carries $2.0/40 = 0.05$ A, so the reading increases.
- 3 V voltmeter: it has a very high resistance, so it takes (almost) no current. The reading does not increase.
- 2.5 V lamp: with 2.0 V across it, the lamp conducts, so the reading increases.
- Diode: X is connected to the positive terminal, so X is at the higher potential. The diode points from X to Y, so it is forward-biased and conducts. The reading increases.

Q27 Answer **D**

Each half of the wire has length $L/2$ and makes an angle θ with the normal to the field, so the angle between the wire and the field is $90° - \theta$.

$$F_{\text{each half}} = BI\left(\frac{L}{2}\right)\sin(90° - \theta) = BI\left(\frac{L}{2}\right)\cos\theta$$

Both halves carry the current downwards across the field, so the two forces are in the same direction:

$$F = BIL\cos\theta$$

Direction: the current is downwards and the field is to the right. By Fleming's left-hand rule, the force is out of the page.

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

Q28 Answer **C**

The path curves upwards in the plane of the paper, so the magnetic force is in the plane of the paper, perpendicular to the velocity.

A field from X to Y lies in the plane of the paper. The force would then be into or out of the paper, and the particle would not curve within the paper. So the field must be into (or out of) the paper.

Check option C with Fleming's left-hand rule: positive particle moving to the right (current to the right), field into the paper. The force is upwards, towards X, matching the path.

(A negative particle with the field into the paper would curve downwards.)

Q29 Answer **A**

Almost all α-particles pass straight through, and only a tiny proportion are deflected through large angles. A large deflection needs a very strong repulsive force, which requires the particle to come very close to a concentrated positive charge. That so few particles do this shows the nucleus occupies only a tiny fraction of the volume of the atom.

Q30 Answer **C**

An α-particle is ${}^{4}_{2}He$. In α-decay the nucleon number falls by 4 and the proton number falls by 2.

$$ {}^{185}_{79}Au \rightarrow {}^{181}_{77}Ir + {}^{4}_{2}He $$

Nucleon number 181, proton number 77.

thelearningcave.com.sg
Physics. Math. Chemistry.