Year 12 Physics

Practice Test

Time Allowed: 1 Hour

Total Marks: 56

27 April 2025

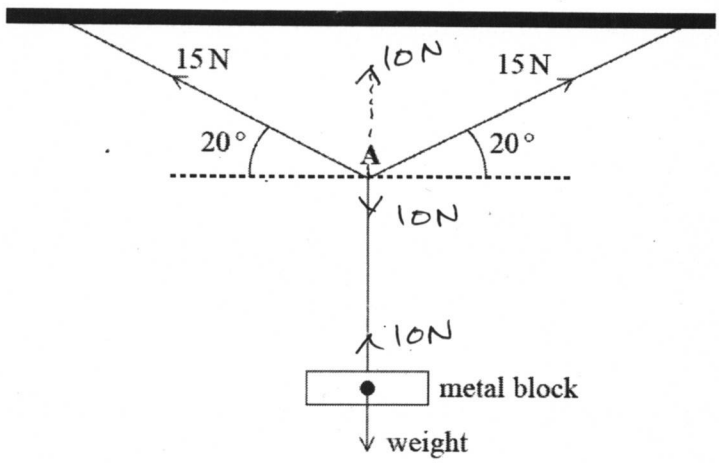
Calculator Allowed

Full Name of Student: .....

1.

Figure 3 shows a stationary metal block hanging from the middle of a stretched wire which is suspended from a horizontal beam. The tension in each half of the wire is 15 N.

Figure 3



(a) Calculate for the wire at **A**,

(i) the resultant horizontal component of the tension forces,

$15\cos 20^\circ - 15\cos 20^\circ = 0\ N$

(ii) the resultant vertical component of the tension forces.

$15\sin 20 + 15\sin 20 = 10.260\ldots$

$= 10\ N\ (2\ sf)$

(3 marks)

(This question continues on the next page)

(b) (i) State the weight of the metal block.

10N (2 s.f.)

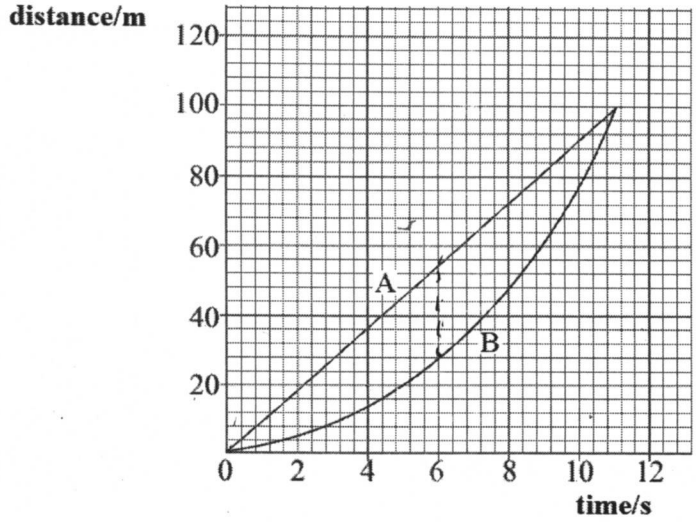
(ii) Explain how you arrived at your answer, with reference to an appropriate law of motion.

Since point A and the metal block ~~weight~~ are in equilibrium, the resultant force on them must be zero according to Newton's 1st law. This means, the tension in the string connecting the metal block must be 10N (2 s.f.) as shown on the diagram. Hence the weight of the block should also be 10N (2 s.f.). *(3 marks)*

[Total for Question 1 = 6 marks]

2.

The distance-time graphs for two runners, A and B, in a 100 m race are shown.



(a) Explain how the graph shows that athlete B accelerates throughout the race.

Gradient of the distance-time graphs is speed. The gradient increases for B.

(1 mark)

(b) Estimate the maximum distance between the athletes.

26m

(1 mark)

(c) Calculate the speed of athlete A during the race.

Speed = gradient = $\frac{76}{8.2}$ = 9.3 m/s

(1 mark)

(d) The acceleration of athlete B is uniform for the duration of the race.

(i) State what is meant by uniform acceleration.

The magnitude and direction of acceleration remain the same.

(ii) Calculate the acceleration of athlete B.

$s = ut + \frac{1}{2}at^2$

$100 = 0 + \frac{1}{2}a(11)^2$

$a = 1.652\ldots$

$a = 1.7\ ms^{-2}$ (2 s.f.)

(3 marks)

[Total for Question 2 = 6 marks]

3.

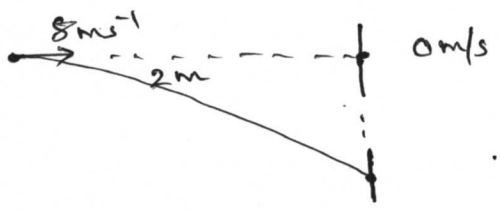
A dart is thrown horizontally at a speed of $8.0\ m\ s^{-1}$ towards the centre of a dartboard that is 2.0 m away. At the same instant that the dart is released, the support holding the dartboard fails and the dartboard falls freely, vertically downwards. The dart hits the dartboard in the centre before they both reach the ground.

(a) State and explain the motion of the dart and the dartboard, while the dart is in flight.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

If air resistance is ignored, the only force acting on the two objects is their weight. This causes both the objects to have a vertical acceleration of downwards $9.81\ ms^{-2}$. As a result, the dartboard moves vertically downwards, while the dart moves along a parabolic path due to its initial velocity being horizontal.

(4 marks)



(b) Calculate

(i) the time taken for the dart to hit the dartboard,

$s = vt$

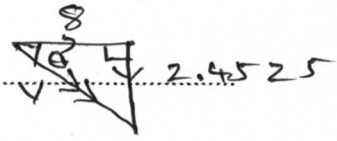
$2 = 8t \Rightarrow t = 0.25$ sec

(ii) the vertical component of the dart's velocity just before it strikes the dartboard,

~~$s = ut + \frac{1}{2}at$~~ $v = u + at$

$v = 0 + 9.81(0.25) = 2.4525 = 2.5 \text{ ms}^{-1}$ (2 s.f.)

(iii) the magnitude and direction of the resultant velocity of the dart as it strikes the dartboard.



$v = \sqrt{8^2 + 2.4525^2}$

$= 8.4 \text{ ms}^{-1}$ (2 s.f.)

$\theta = \tan^{-1}\left(\frac{2.4525}{8}\right)$

$= 17.04...$

$= 17°$ (2 s.f.) below the horizontal

(5 marks)

[Total for Question 3 = 9 marks]

4.

The 'Stealth' roller coaster at the Thorpe Park theme park is advertised as reaching 135 km hour^{-1} from rest in 2.3 seconds.

Most roller coasters are driven slowly up to the top of a slope at the start of the ride. However the carriages on 'Stealth' are initially accelerated horizontally from rest at ground level by a hydraulic launch system, before rising to the top of the first slope.

(a) (i) Calculate the average acceleration of the carriages.

135 km hour^{-1} = 37.5 m s^{-1}

(2)

$v = u + at$

$37.5 = 0 + a(2.3)$

$a = 16.304...$

$a = 16 \text{ ms}^{-2}$ (2 s.f.)

Average acceleration = 16 ms^{-2}

(ii) Calculate the minimum average power which must be developed by the launch system.

mass of carriages and passengers = 10 000 kg

(3)

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(10000)37.5^2 = 7031250\,J$

$P = \frac{7031250}{2.3}$

$= 3057065.217\,W$

$= 3.1\,MW$ (2 s.f.)

Minimum average power = 3.1 MW

(iii) Suggest why the power in (ii) is a minimum value.

(1)

The above calculation assumes that all the energy transferred by the launch system will be transferred as kinetic energy. However, some energy will be lost due to friction an air resistance. Hence actual energy transferred will be greater.

(b) The force required to launch 'Stealth' is not always the same. The ride is monitored and the data from preceding launches is used to calculate the required force.

If the mass of the passengers for a particuiar ride is significantly more than for preceding launches, this can lead to 'rollback'. This is when the carriages do not quite reach the top of the first slope and return backwards to the start.

Explain why 'rollback' would occur in this situation.

(3)

Assuming no resistive forces, the energy transferred by the launch system must be greater than or equal to the gravitation potential energy gained when the carriages reach the top of the first slope to prevent roll back. If the mass is significanly greater, the gravitational potential energy need to be gained will be greater. If the lauch system doesn't transfer enough energy, this will not be possible. Hence rollback occurs.

[Total for Question 4 = 9 marks]

5.

The photograph shows a typical hairdryer.

(a) The hairdryer contains a heating element which consists of a long nichrome wire wound around an insulator. The heating element operates at 230 V and has a power rating of 1 kW.

Show that the resistance of the heating element is about 50 Ω.

(3)

$P = \frac{V^2}{R}$

$1000 = \frac{230^2}{R}$

$R = 52.9\,\Omega \approx 50\,\Omega$

(b) The nichrome wire has a cross-sectional area of 1.3×10^{-7} m^2.

Calculate the length of the wire.

resistivity of nichrome = 1.1×10^{-6} Ω m

(2)

$R = \frac{\rho l}{A}$

$l = \frac{RA}{\rho} = \frac{52.9 \times 1.3 \times 10^{-7}}{1.1 \times 10^{-6}}$

$= 6.2518\ldots = 6.3\text{ m}$ (2 s.f.)

Length = 6.3 m (2 s.f.)

(c) The nichrome wire has a diameter of 0.40 mm. A manufacturer wishes to make a hairdryer of the same resistance but using half the length of wire.

Calculate the diameter of nichrome wire that must be used.

(3)

$R = \frac{\rho l}{A} \Rightarrow A = \frac{\rho l}{R}$

As ρ and R remain the same,

$A \propto l$

When l halves, A halves as well.

$A = \pi r^2 \Rightarrow A \propto r^2 \Rightarrow r$ gets multiplied by $\frac{1}{\sqrt{2}}$.

Same factor for D. $D = \frac{1}{\sqrt{2}} \times 0.40 = 0.28$ (2 s.f.)

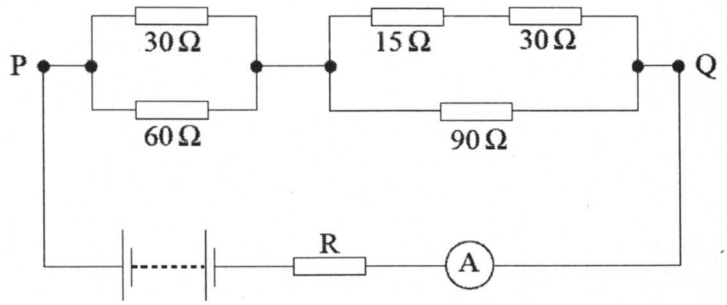
Diameter = 0.28 mm.

[Total for Question 5 = 8 marks]

6.

In the circuit shown in **Figure 1** the resistor network between the points P and Q is connected in series to a resistor R, an ammeter and a battery of negligible internal resistance.

Figure 1



(a) Determine the equivalent resistance of the network between the points P and Q.

$\frac{1}{R} = R = \frac{30 \times 60}{30+60} = 20\,\Omega$, $R = \frac{90 \times 45}{90+45} = 30\,\Omega$

R_T between P & Q $= 20 + 30$

$= 50\,\Omega$

(3 marks)

(b) (i) If the current through the ammeter is 50 mA, calculate the total charge that flows through the resistor R in 4 minutes.

$Q = It = 50 \times 10^{-3} \times 4 \times 60 = 12\ C$ //

(ii) If 18 J of energy are transferred to the resistor R in this time, calculate the potential difference across R.

$E = QV$

$18 = 12V \Rightarrow V = 1.5\ V$ //

(iii) Calculate the resistance of R.

$V = IR$ for R

$1.5 = 50 \times 10^{-3} R \Rightarrow R = 30\ \Omega$ //

(iv) Calculate the emf of the battery.

R_T in the circuit $= 50 + 30 = 80\ \Omega$

$V = IR$ for the whole circuit

$V = 50 \times 10^{-3} \times 80$ *(6 marks)*

$= 4\ V$ //

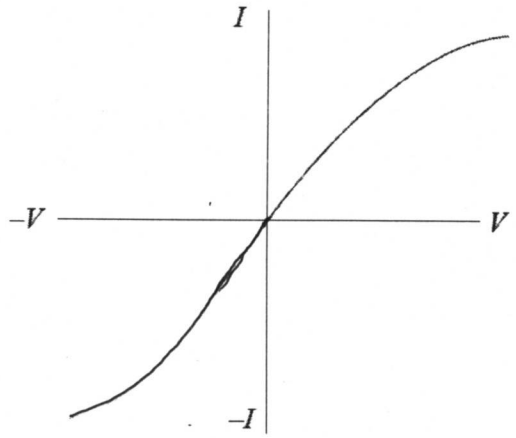
[Total for Question 6 = 9 marks]

Question 7 is on the next page.

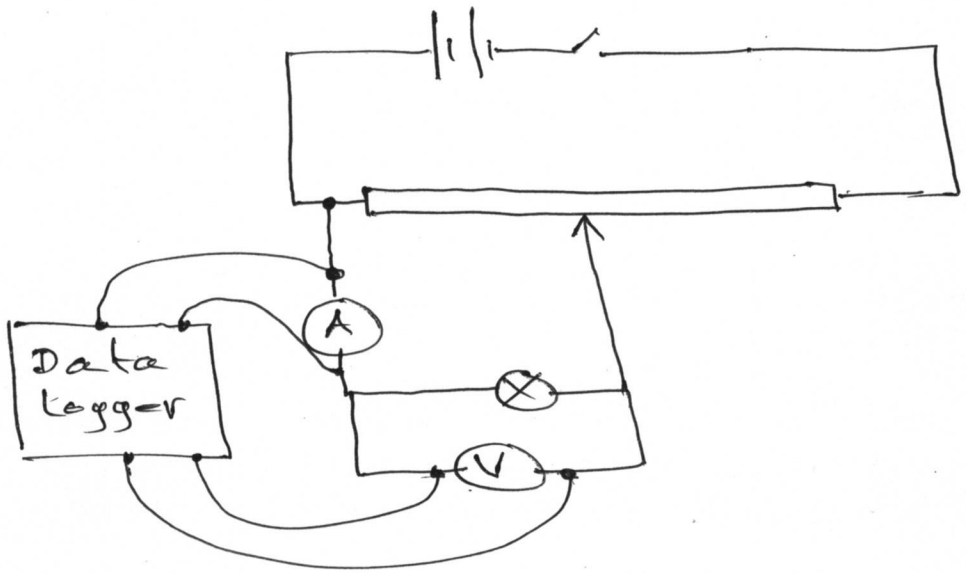
7.

Figure 3 shows the positive part of the $I - V$ characteristic for a filament lamp when the current through it is in the positive direction.

Figure 3



(a) (i) Draw the circuit diagram of an experimental arrangement which could be used to collect the data necessary to produce this graph. Your circuit should include a potential divider and a data logger. Label the filament lamp clearly.



(ii) On **Figure 3** complete the characteristic when the current through the filament lamp is reversed.

(5 marks)

(b) Explain the shape of the complete $I - V$ characteristic.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

~~When~~ As the potential difference across the lamp is increased, current through it increases. This increases the collision between the moving electrons and the metal ions. As a result, the metal ions vibrate more (temperature increases. Hence the resistance of the filament increases. Due to this, even though the current increases, its increase is limited and ~~therefore the current~~ and it doesn't increase in proportion to the potential difference. *(4 marks)*

[Total for Question 7 = 9 marks]

- End of Test -