MA99 EDUCATION

Physics: Practice Paper 1 01

NSW PHYSICS 11-12 SYLLABUS 2025 FOR HSC 2028 AND LATER

1. Instructions

Practice Paper 1 is a full Year 11 yearly examination on all three focus areas, Fundamentals of mechanics, Waves, and Electricity and magnetism, with Working scientifically throughout. It follows the shape of NESA's HSC examination specification for the new syllabus: 100 marks, 3 hours plus 10 minutes reading time, Section I of 20 multiple choice questions and Section II of 21 items. Complete it under timed conditions with a calculator, then mark it against the guidance at the back. Papers 1 to 3 rise slightly in difficulty, and Paper 1 is the most direct of them: most of its items take one or two steps.

General instructions

- Reading time: 10 minutes.
- Working time: 3 hours.
- Write using black pen.
- A NESA approved calculator may be used. A pair of compasses and a protractor may be used.
- Use the data in the note below and NESA's HSC Physics formulae sheet.
- For questions in Section II, show all relevant working in questions involving calculations.

Total marks: 100

Section I, 20 marks. Attempt Questions 1 to 20. Allow about 35 minutes for this section. Section II, 80 marks. Attempt Questions 21 to 41. Allow about 2 hours and 25 minutes for this section.

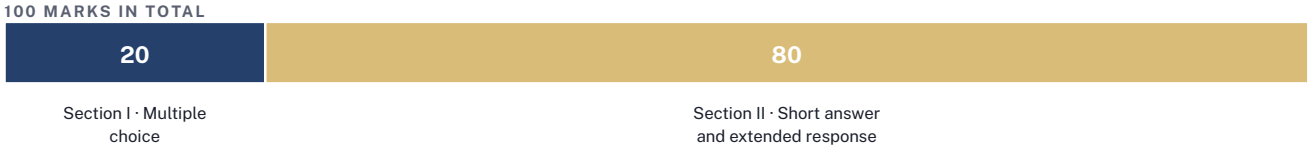


Figure 1 · How the 100 marks are split across the sections. Your time should follow the same split.

Contexts and data in this paper

The contexts are everyday ones: a skate park, a train in the rain, a supermarket trolley, a phone on a textbook, a car alarm and a hair dryer. All investigation data are hypothetical, written for MA99 and labelled so. The one real-world reference, the Gundungurra example in Question 14, is the example NESA gives for the law of reflection.

Data and formulae for this paper

The values below are those on NESA's sample 2028 HSC Physics data sheet. Every formula you need is on NESA's formulae sheet except $a = g\sin\theta - \mu g\cos\theta$, which you must be able to derive.

QUANTITY	VALUE
Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Speed of sound in air	340 m/s
Acceleration due to gravity, g	9.8 m/s^2
Speed of light, c	3.00×10^{8} m/s
Electric permittivity constant, ε_0	8.854×10^{-12} A^2 s^4 kg^{-1} m^{-3}
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7}$ N A^{-2}
Planck constant, h	6.626×10^{-34} J s

Useful: $\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}$ N m^2 C^{-2}. Prefixes: p 10^{-12}, n 10^{-9}, μ 10^{-6}, m 10^{-3}, k 10^{3}, M 10^{6}, G 10^{9}.

2. Section I · Multiple choice

Section I

20 marks. Attempt Questions 1 to 20. Allow about 35 minutes for this section. Select the alternative A, B, C or D that best answers the question.

2.1 Section I answer grid

Circle the letter on the question, then copy it into the grid.

Q	1	2	3	4	5	6	7	8	9	10
Q	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**

Question 1

1 MARK

A student lists four quantities: displacement, speed, acceleration and time. Which two are scalar quantities?

A Displacement and time
B Speed and acceleration
C Speed and time
D Displacement and acceleration

Question 2

1 MARK

A skateboarder rolls 12 m east along a path, stops, then rolls 5 m west. What are the distance travelled and the displacement?

A 17 m; 7 m east
B 7 m; 17 m east
C 17 m; 17 m east
D 7 m; 7 m west

Question 3

1 MARK

The displacement-time graph for a trolley is a straight line sloping downwards. Which describes the motion of the trolley?

A It accelerates in the negative direction.

B It moves with constant velocity in the negative direction.

C It slows down until it stops.

D It is stationary at a negative position.

Question 4

1 MARK

A car accelerates uniformly from rest at 2.5 m/s^2 for 6.0 s. How far does it travel in this time?

A 90 m

B 15 m

C 7.5 m

D 45 m

Question 5

1 MARK

A hot-air balloon rises vertically at a constant velocity. Which statement about the forces on the balloon is correct?

A The upward force is greater than the weight, because the balloon is rising.

B The net force is upward and constant.

C The forces on it are balanced, so the net force is zero.

D No forces act on it, because its velocity is constant.

Question 6

1 MARK

The speed of a 1200 kg car increases from 10 m/s to 16 m/s in 4.0 s, in a straight line. What is the net force on the car?

A 1800 N

B 4800 N

C 3000 N

D 7200 N

Question 7

1 MARK

A rocket in deep space switches on its engine and pushes exhaust gas out backwards. According to Newton's third law, which force pushes the rocket forwards?

A The force of the exhaust gas pushing against the air behind the rocket.

B The force of the rocket on the exhaust gas.

C A forward force larger than the backward force on the gas, which is why the rocket speeds up.

D The force of the exhaust gas on the rocket, equal in size to the force of the rocket on the gas.

Question 8

1 MARK

A 0.20 kg ball is thrown vertically upwards at 6.0 m/s. Ignoring air resistance, what is the greatest height it rises above the point of release?

A 0.31 m

B 1.8 m

C 3.7 m

D 0.37 m

Question 9

1 MARK

A tuning fork vibrates with a period of 2.5 ms. What are the frequency of the sound and its wavelength in air?

A 400 Hz and 0.85 m

B 400 Hz and 1.2 m

C 0.40 Hz and 850 m

D 400 Hz and 1.4×10^5 m

Question 10

1 MARK

In a longitudinal wave, the wavelength is the distance between

A a compression and the next rarefaction.

B the rest position of a particle and the centre of a compression.

C the centres of two adjacent compressions.

D two neighbouring particles of the medium.

Question 11

1 MARK

An electric bell rings inside a sealed glass jar. As the air is pumped out, the ringing fades until it cannot be heard, but the bell can still be seen vibrating. Which statement best explains this?

A The glass absorbs sound but lets light through.

B Sound is a mechanical wave that needs a medium; light is an electromagnetic wave that does not.

C Sound travels more slowly than light, so it cannot escape the jar.

D Removing the air lowers the frequency of the sound below the range of hearing.

Question 12

1 MARK

A photon has an energy of 3.3×10^{-19} J. What is its frequency, and in which region of the electromagnetic spectrum does it lie?

A 5.0×10^{14} Hz; X-rays

B 2.2×10^{-52} Hz; radio waves

C 6.0×10^{-7} Hz; infrared

D 5.0×10^{14} Hz; visible light

Question 13

1 MARK

Light passes from air into water (n = 1.33) with an angle of incidence of 50°. What is the angle of refraction?

A 35°

B 38°

C 55°

D 50°

Question 14

1 MARK

NESA's example for the law of reflection is the Gundungurra People reflecting a beam of sunlight each year from the Southern Highlands to the Blue Mountains. Sunlight strikes a plane mirror at 25° to the surface of the mirror. What is the angle of reflection?

A 25°

B 65°

C 130°

D 155°

Question 15

1 MARK

A negatively charged rod is held near, but not touching, one side of a neutral metal sphere on an insulating stand. Which describes the sphere while the rod is held there?

A Electrons jump from the rod to the sphere, so the sphere becomes negative.

B Protons move towards the rod, so the near side becomes positive.

C Electrons are repelled to the far side, so the near side is positive and the sphere's total charge is still zero.

D Nothing happens, because the rod does not touch the sphere.

Question 16

1 MARK

An electron is in a uniform electric field of strength 2.0×10^{4} N/C directed east. What is the electric force on the electron?

A 3.2×10^{-15} N east

B 1.2×10^{23} N west

C 8.0×10^{-24} N west

D 3.2×10^{-15} N west

Question 17

1 MARK

A charge of 90 C flows through a lamp in 1.5 minutes. What is the current in the lamp?

A 60 A

B 1.0 A

C 135 A

D 0.017 A

Question 18

1 MARK

A hair dryer is rated 1800 W at 240 V. What is the resistance of its heating element when it operates?

A 32 Ω

B 7.5 Ω

C 0.13 Ω

D 0.031 Ω

Question 19

1 MARK

A 12 Ω resistor and a 6.0 Ω resistor are connected in parallel. What is their total resistance?

A 18 Ω

B 9.0 Ω

C 4.0 Ω

D 0.25 Ω

Question 20

1 MARK

The magnetic field strength 4.0 cm from a long straight wire is B. The current in the wire is doubled. What is the field strength 8.0 cm from the wire?

A $B/2$

B $2B$

C $4B$

D B

3. Section II · Short answer and extended response

Section II

80 marks. Attempt Questions 21 to 41. Allow about 2 hours and 25 minutes for this section. Answer the questions in the spaces provided. Show all relevant working in questions involving calculations, and give answers with units and sensible significant figures.

Question 21

3 MARKS

A ferry travels 3.0 km in a direction 30° north of east, then 4.0 km due north. The whole trip takes 20 minutes.

(a) Calculate the ferry's displacement for the whole trip. (2 marks)

(b) Calculate the ferry's average velocity for the trip, in m/s. (1 mark)

Question 22

4 MARKS

A data logger recorded the velocity of a toy car moving in a straight line on a level floor (hypothetical data).

Time, T (s)	0	1.0	2.0	3.0	4.0	5.0	6.0
Velocity, v (m/s)	0.00	0.62	1.18	1.81	2.40	2.41	2.39

(a) On the grid in Figure 2, construct a velocity-time graph of the data, with lines of best fit. (2 marks)

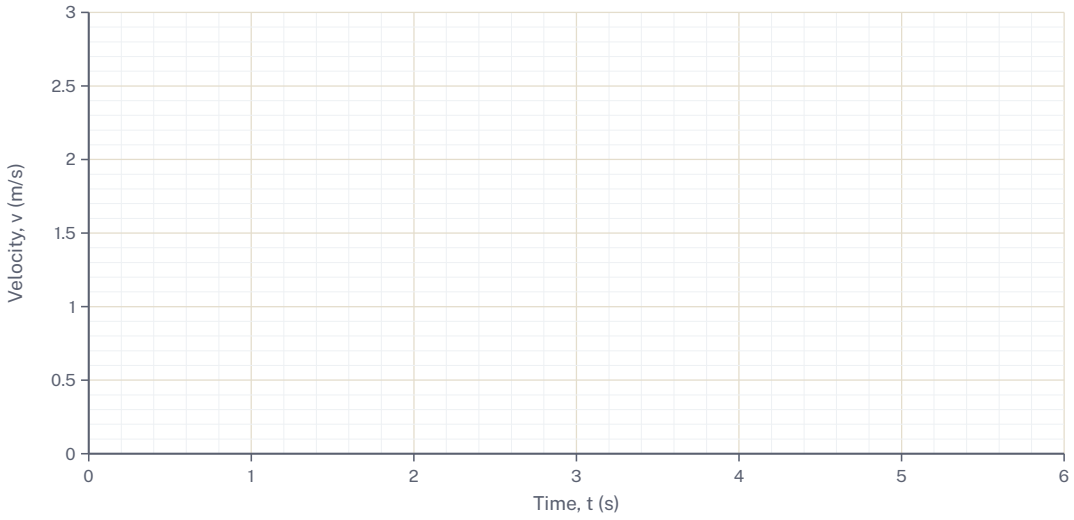


Figure 2 · Grid for Question 22.

(b) Use your graph to determine the acceleration of the car during the first 4.0 s. (1 mark)

(c) Use your graph to determine the displacement of the car over the 6.0 s. (1 mark)

Question 23

3 MARKS

Rain falls vertically at 7.5 m/s relative to the ground. A passenger on a train travelling due east at 18 m/s sees the raindrops run in straight, sloping streaks down the side window.

(a) Using $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$, calculate the velocity of the rain relative to the train. (2 marks)

(b) Explain why the streaks slope backwards, towards the rear of the train. (1 mark)

Question 24

7 MARKS

A student investigated the relationship between force and acceleration. A trolley on a level track was pulled by a string over a pulley attached to a hanging mass. To increase the force, the student moved slotted masses one at a time from the trolley onto the hanger. The total mass of the trolley, slotted masses and hanger was 0.85 kg throughout. The acceleration was measured with a motion sensor (hypothetical data).

ACCELERATING FORCE, F (N)	0.20	0.40	0.60	0.80	1.00
Acceleration, a (m/s^2)	0.19	0.44	0.66	0.91	1.13

(a) Justify the student's method of increasing the force by moving masses from the trolley to the hanger, rather than adding new masses to the hanger. (2 marks)

(b) On the grid in Figure 3, plot the data and draw a line of best fit. (2 marks)

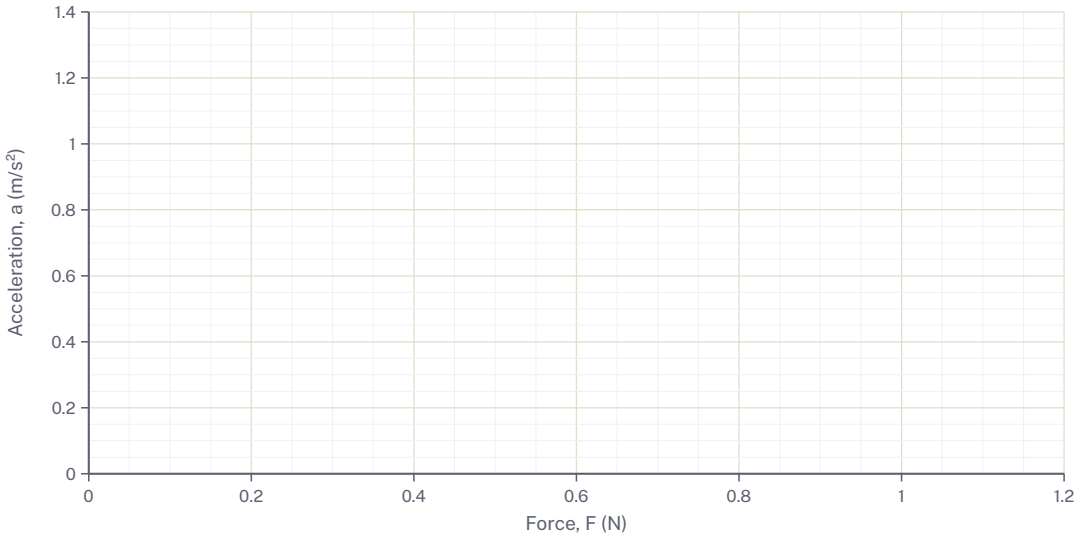


Figure 3 · Grid for Question 24.

(c) Use the gradient of your line to determine the mass being accelerated, and explain why the line does not pass through the origin. (3 marks)

Question 25

3 MARKS

Two boxes, A (6.0 kg) and B (4.0 kg), sit side by side and touching on a smooth, level floor. A student pushes box A horizontally with a force of 30 N, so that A pushes B along.

(a) Calculate the acceleration of the boxes. (1 mark)

(b) Calculate the force that box A exerts on box B. (1 mark)

(c) The student now pushes box B with 30 N in the opposite direction, so that B pushes A. Explain why the force between the boxes is now larger. (1 mark)

Question 26

5 MARKS

A phone lies on a textbook. One end of the book is slowly lifted. The phone starts to slide when the angle of the book reaches 28°.

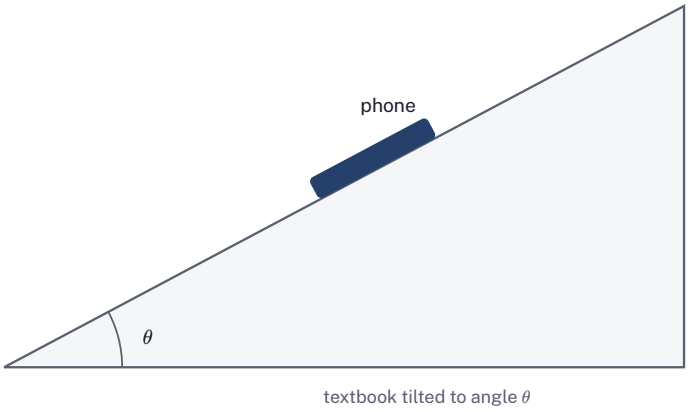


Figure 4 · The phone on the tilted textbook.

(a) Draw a labelled free-body diagram of the phone just before it starts to slide. (2 marks)

(b) Show that the coefficient of static friction between the phone and the book is about 0.53. (1 mark)

(c) Once the phone is sliding, the coefficient of kinetic friction is 0.40. Explain why the phone accelerates down the book at 28°, and calculate its acceleration. (2 marks)

Question 27

3 MARKS

A shopper pushes a 20 kg trolley, initially at rest, 15 m across a level car park. The push is 60 N, directed at 30° below the horizontal. A resistive force of 40 N acts on the trolley throughout.

(a) Calculate the work done by the push. (1 mark)

(b) Calculate the speed of the trolley after 15 m. (2 marks)

Question 28

4 MARKS

Two trolleys, P (1.2 kg) and Q (0.80 kg), are held at rest on a level, low-friction track with a compressed spring between them. When they are released, Q moves away at 0.60 m/s.

(a) Calculate the velocity of P after the release. (2 marks)

(b) The total momentum after the release is the same as before, but the total kinetic energy has increased. Explain both of these observations. (2 marks)

Question 29

4 MARKS

In a practical investigation, a student uses a computer simulation that shows a wave passing through a row of particles. One particle is coloured red. In simulation 1 each particle moves up and down while the wave travels to the right. In simulation 2 each particle moves left and right while the wave travels to the right.

(a) Classify the wave in each simulation, and relate the direction in which the particles oscillate to the direction of energy transfer in each. (2 marks)

(b) After the wave has passed, the red particle is back where it started. Explain what this shows about what a wave transfers. (2 marks)

Question 30

4 MARKS

Figure 5 shows a wave on a rope at one instant. The wave travels to the right at 4.0 m/s.

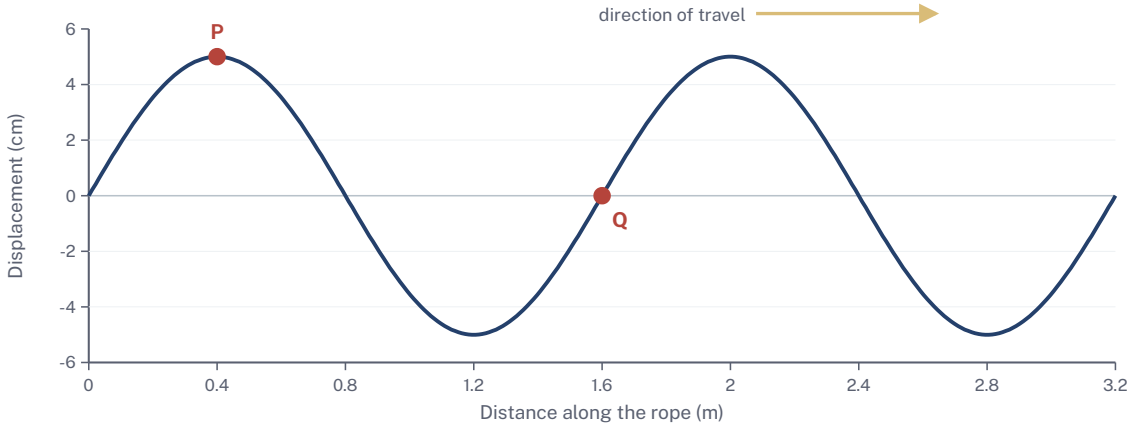


Figure 5 · Displacement against distance along a rope at one instant.

(a) State the amplitude and the wavelength of the wave. (1 mark)

(b) Calculate the frequency and the period of the wave. (2 marks)

(c) Point P is at a crest and point Q is at zero displacement. State the direction in which the rope at Q is moving at this instant. (1 mark)

Question 31

5 MARKS

In a practical investigation, a signal generator drove a loudspeaker. Two microphones connected to an oscilloscope were placed in front of it, and one was moved away from the speaker until the two traces were back in step; the distance moved was one wavelength. The student repeated this at five frequencies (hypothetical data).

Frequency, f (Hz)	500	750	1000	1500	2000
Wavelength, λ (m)	0.69	0.45	0.34	0.23	0.17

(a) Describe the relationship between wavelength and frequency. Support your answer with the data. (2 marks)

(b) Use the data to determine the speed of sound in the room. (1 mark)

(c) The student listened to the speaker as the frequency was raised, then as the amplitude was raised. Describe what the student heard in each case. (1 mark)

(d) Identify one hazard in this investigation and a way to manage its risk. (1 mark)

Question 32

4 MARKS

A ray of light strikes the top surface of a rectangular perspex block (n = 1.49) at an angle of incidence of 45°, as shown in Figure 6.

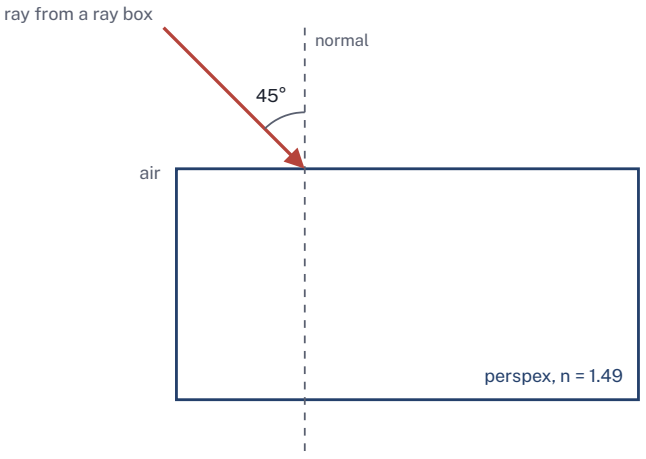


Figure 6 · A ray of light incident on a perspex block.

(a) Calculate the angle of refraction in the perspex. (2 marks)

(b) Calculate the speed of light in the perspex. (1 mark)

(c) On Figure 6, complete the path of the ray through the block and out of the bottom surface. (1 mark)

Question 33

3 MARKS

A parked car's alarm emits sound of frequency 1200 Hz. A cyclist rides towards the car at 8.0 m/s on a still day.

(a) Calculate the frequency heard by the cyclist. (2 marks)

(b) Explain what happens to the frequency the cyclist hears as she passes the car and rides away. (1 mark)

Question 34

2 MARKS

Outline one practical application of infrared radiation, linking a property of infrared radiation to the use.

Question 35

3 MARKS

A rubber balloon is rubbed on a woollen jumper. It then sticks to a neutral, painted wall.

(a) Explain, in terms of the movement of electrons, how the balloon becomes negatively charged. (1 mark)

(b) Explain why the negatively charged balloon is attracted to the neutral wall. (2 marks)

Question 36

3 MARKS

(a) Figure 7 shows two point charges of equal size and opposite sign. Draw the electric field between and around them, using at least eight field lines. (2 marks)



Figure 7 · Two point charges, +q and −q.

(b) Calculate the electric field strength 0.30 m from a point charge of $+4.0\ \mu$C. (1 mark)

Question 37

2 MARKS

Compare the direct current supplied by a car battery with the alternating current supplied by a household power point.

Question 38

5 MARKS

In a laboratory experiment, a student measured the current through two components, X and Y, at voltages from 0 to 6.0 V. Figure 8 shows the results.

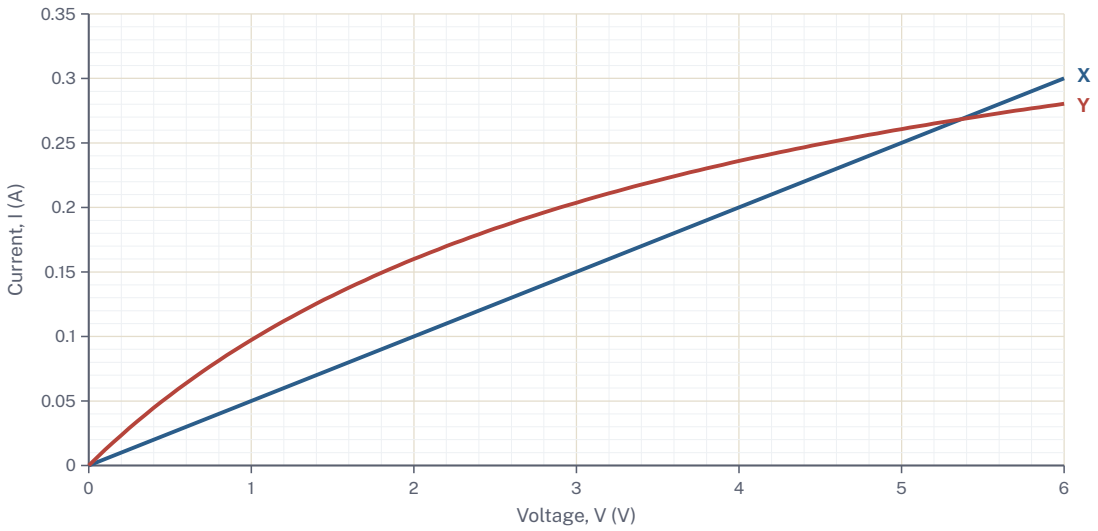


Figure 8 · Current against voltage for components X and Y (hypothetical data).

(a) Identify which component is an ohmic conductor. Justify your answer. (1 mark)

(b) Component Y is a filament lamp. Calculate its resistance at 2.0 V and at 6.0 V. (2 marks)

(c) Explain why the resistance of the lamp changes as the voltage increases. (1 mark)

(d) A student says, “The resistance of the lamp at 6.0 V is the gradient of the curve at 6.0 V.” Explain why the student is wrong. (1 mark)

Question 39

4 MARKS

Figure 9 shows a combination circuit. The supply provides 12 V and its own resistance can be ignored.

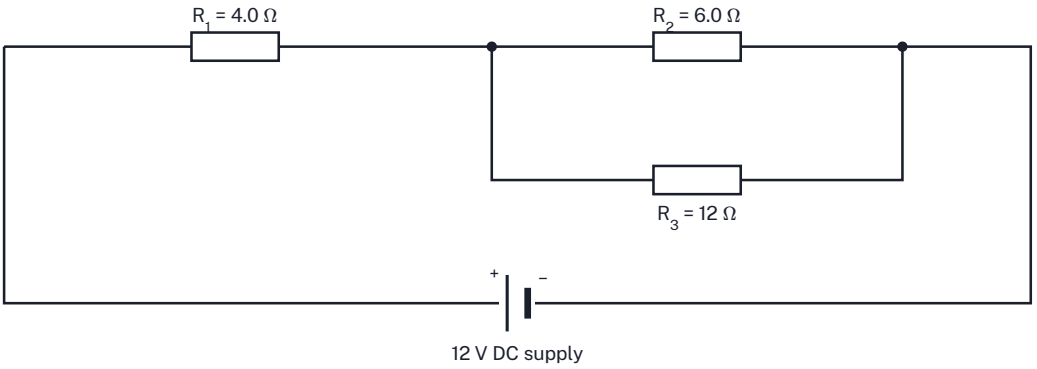


Figure 9 · A combination circuit.

(a) Calculate the total resistance of the circuit. (1 mark)

(b) Calculate the current in R_2. (2 marks)

(c) Calculate the power dissipated in R_3. (1 mark)

Question 40

2 MARKS

A student wants to measure the current through R_3 and the voltage across it in the circuit of Figure 9. Explain how the ammeter and the voltmeter must be connected, and why each meter must be designed the way it is.

Question 41

7 MARKS

A student made an electromagnet by winding 120 turns of insulated copper wire along 6.0 cm of an iron nail. To examine how the current affects its strength, the student counted the steel paper clips the nail could lift, once at each current (hypothetical data).

CURRENT, I (A)	0.5	1.0	1.5	2.0	2.5
Paper clips lifted	3	7	10	14	15

(a) Calculate the magnetic field strength the coil would produce inside itself at 2.0 A if the nail were removed. (2 marks)

(b) Explain why the iron nail makes the electromagnet much stronger than the coil alone. (1 mark)

(c) Describe the relationship shown by the results, and suggest one reason for the result at 2.5 A. (2 marks)

(d) Assess the validity and reliability of the method, and propose one improvement for each. (2 marks)

End of paper.

3.1 Section II extra writing space

If you use this space, clearly write the number of the question you are answering.

4. Marking guidance

Mark the paper after completing it under timed conditions. The criteria are MA99's own, written in the style of NESA marking guidelines; the sample answers show where each mark is earned.

> Mark Section I first. Two minutes, and it tells you which topics to reread before you mark the rest.

4.1 Section I · Answer key

One mark each. Every distractor is a real error, so a wrong letter names the step you need to fix.

Q	ANSWER	WHY THE KEY IS RIGHT, AND THE ERROR BEHIND EACH OTHER OPTION
1	C	Speed and time have size only. Displacement and acceleration have direction as well, so they are vectors. (A) treats displacement as if it were distance. (B) treats acceleration as a size only. (D) picks the two vectors.
2	A	Distance adds the path lengths, 12 + 5 = 17 m. Displacement is the change in position, 12 − 5 = 7 m east. (B) swaps the two quantities. (C) treats the total path as the displacement. (D) takes the direction of the last leg.
3	B	The gradient of a displacement-time graph is velocity. A straight line has a constant gradient, and a negative gradient means motion in the negative direction. (A) reads the gradient as acceleration. (C) reads "downwards" as "slowing". (D) describes a horizontal line below the axis.
4	D	$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}(2.5)(6.0)^2 = 45$ m. (A) leaves out the ½. (B) gives the final speed, $v = at = 15$ m/s, as a distance. (C) uses $\frac{1}{2}at$ and forgets to square the time.
5	C	Constant velocity means zero acceleration, so by Newton's first law the net force is zero: the upward force equals the weight plus drag. (A) confuses moving upward with accelerating upward. (B) a constant net force would give a constant acceleration, not a constant velocity. (D) forces act; they are balanced.
6	A	$a = (16 - 10) \div 4.0 = 1.5$ m/s², so $F_{net} = ma = 1200 \times 1.5 = 1800$ N. (B) uses $16 \div 4.0$ as the acceleration. (C) uses $10 \div 4.0$ as the acceleration. (D) multiplies the change in velocity by the mass and forgets the time.
7	D	Third law pairs are equal in size, opposite in direction and act on different objects: the rocket pushes the gas back, the gas pushes the rocket forward. (A) there is no air in deep space, and none is needed. (B) that force acts on the gas, not on the rocket. (C) thinks the pair is unequal when something accelerates.
8	B	$\frac{1}{2}mv^2 = mg\Delta h$, so $\Delta h = v^2 \div 2g = 36 \div 19.6 = 1.8$ m. The mass cancels. (A) uses $v \div 2g$ and forgets to square the speed. (C) uses $v^2 \div g$ and leaves out the 2. (D) divides the kinetic energy, 3.6 J, by g and leaves out the mass.
9	A	$f = 1/T = 1 \div 0.0025 = 400$ Hz; $\lambda = v/f = 340 \div 400 = 0.85$ m. (B) uses $\lambda = f/v$. (C) takes the period as 2.5 s. (D) multiplies the speed by the frequency.
10	C	A wavelength is one complete cycle, compression to the next compression (or rarefaction to the next rarefaction). (A) gives half a wavelength. (B) confuses wavelength with a distance in the direction of oscillation. (D) describes the spacing of particles, not the wave.
11	B	With no air there is no medium for the sound, but light crosses a vacuum. (A) the bell was heard through the same glass at the start. (C) speed does not decide whether a wave can travel. (D) the medium does not set the frequency; the bell does.
12	D	$f = E/h = 3.3 \times 10^{-19} \div 6.626 \times 10^{-34} = 5.0 \times 10^{14}$ Hz, a wavelength of 600 nm: visible light. (A) right frequency, wrong region: X-ray frequencies are about 10^{16} Hz and higher. (B) multiplies E by h. (C) calculates the wavelength in metres and labels it a frequency.
13	A	$\sin\theta_2 = \sin 50^\circ \div 1.33 = 0.576$, so $\theta_2 = 35^\circ$. (B) divides the angle by n instead of its sine. (C) gives the angle from the surface, not the normal. (D) assumes no change of direction.
14	B	Angles are measured from the normal: the angle of incidence is 90 − 25 = 65°, and the angle of reflection equals it. (A) measures from the mirror surface. (C) gives the angle between the incident and reflected rays. (D) takes 180 − 25.
15	C	This is the first step of charging by induction: electrons move within the conductor; none are added or removed. (A) describes conduction, which needs contact. (B) protons are fixed in the nuclei; only electrons move. (D) the field of the rod acts without contact.

Q	ANSWER	WHY THE KEY IS RIGHT, AND THE ERROR BEHIND EACH OTHER OPTION
16	D	$F = qE = 1.602 \times 10^{-19} \times 2.0 \times 10^{4} = 3.2 \times 10^{-15}$ N. A negative charge is pushed opposite to the field. (A) forgets that the charge is negative. (B) divides E by q. (C) divides q by E.
17	B	$I = q/t = 90 \div 90 = 1.0$ A, with the time in seconds. (A) leaves the time in minutes. (C) multiplies charge by time. (D) divides time in minutes by charge.
18	A	$I = P/V = 7.5$ A, then $R = V/I = 240 \div 7.5 = 32\,\Omega$ (or $R = V^2/P$). (B) stops at the current and labels it a resistance. (C) divides voltage by power. (D) divides power by voltage squared.
19	C	$\frac{1}{R} = \frac{1}{12} + \frac{1}{6.0} = \frac{3}{12}$, so $R = 4.0\,\Omega$, less than the smaller resistor. (A) adds them as if in series. (B) averages them. (D) stops at $1/R$ and forgets to invert.
20	D	$B = \frac{\mu_0 I}{2\pi r}$: doubling I doubles B, doubling r halves it, so the field is unchanged. (A) treats the field of a wire as an inverse square law. (B) doubles for the current and ignores the distance. (C) doubles for the current and again for the distance.

4.2 Section II · Criteria and sample answers

QUESTION 21 · 3 MARKS

- (a) 2 marks: components or a vector diagram with the resultant (1); 6.1 km at 65° north of east (1).
- (b) 1 mark: 5.1 m/s at 65° north of east (direction needed).

Sample answer. (a) First leg: east $3.0 \cos 30^\circ = 2.60$ km, north $3.0 \sin 30^\circ = 1.50$ km. Total: east 2.60 km, north $1.50 + 4.0 = 5.50$ km. Magnitude $\sqrt{2.60^2 + 5.50^2} = 6.08$ km; direction $\tan^{-1}(5.50 \div 2.60) = 64.7^\circ$. Displacement: 6.1 km at 65° north of east. (b) $\vec{v}_{av} = \Delta\vec{s}/\Delta t = 6083 \div 1200 = 5.1$ m/s at 65° north of east.

QUESTION 22 · 4 MARKS

- (a) 2 marks: axes used as given, all seven points plotted accurately (1); a straight line through the origin for 0 to 4.0 s and a horizontal line at about 2.4 m/s from 4.0 to 6.0 s (1).
- (b) 1 mark: gradient of the first line, 0.60 m/s^2 (accept 0.58 to 0.62).
- (c) 1 mark: area under the graph, $\frac{1}{2}(4.0)(2.4) + (2.0)(2.4) = 9.6$ m in the direction of motion (accept 9.4 to 9.8 m).

Common error

Joining the points dot to dot. “Construct a graph from data” means lines of best fit: here, two straight lines that meet at 4.0 s, not a wobbly path through every reading.

QUESTION 23 · 3 MARKS

- (a) 2 marks: $\vec{v}_{RT} = \vec{v}_R - \vec{v}_T$, shown as 7.5 m/s down plus 18 m/s west (1); $\sqrt{7.5^2 + 18^2} = 19.5$ m/s, at $\tan^{-1}(18 \div 7.5) = 67^\circ$ from the vertical, slanting towards the west (1).
- (b) 1 mark: relative to the train, each drop moves west (towards the rear) as well as down, because the train’s eastward velocity is subtracted; so the drops trace lines that slope down and backwards.

Sample answer. (a) Subtracting the train’s velocity is adding 18 m/s west. $|\vec{v}_{RT}| = \sqrt{7.5^2 + 18^2} = 19.5$ m/s, at $\tan^{-1}(18 \div 7.5) = 67^\circ$ from the vertical: relative to the train the rain moves at 19.5 m/s, downwards and westwards. (b) Seen from the train, the rain has a westward (backward) velocity of 18 m/s as well as its downward 7.5 m/s, so each streak runs down and towards the back of the train, much closer to horizontal than vertical.

QUESTION 24 · 7 MARKS

MARKS	CRITERIA
6 to 7	Justifies keeping the total mass constant as a controlled variable; plots accurately with a straight line of best fit; uses the gradient to find the mass with working; explains the intercept as friction
4 to 5	Plots the data with a line of best fit and finds the gradient, with a partial justification or explanation

MARKS	CRITERIA
2 to 3	Plots most points, or gives a relevant reason for the method
1	Some relevant information

- (a) 2 marks: the hanging mass is also accelerated, so the mass accelerated is the whole system (1); moving masses keeps the total mass constant, so only the force changes and the test is valid (1).
- (b) 2 marks: five points plotted accurately (1); a single straight line of best fit that does not pass through the origin (1).
- (c) 3 marks: gradient about 1.18 kg^{-1} (accept 1.12 to 1.22) (1); $m = 1/\text{gradient} = 0.85$ kg, matching the measured total mass (1); the line cuts the force axis at about 0.03 N: this much of the force is needed to overcome friction before the trolley accelerates, a systematic error (1).

Sample answer. (a) The accelerating force is the weight of the hanger, but the hanger and the trolley accelerate together, so the mass being accelerated is the whole system. Adding new masses would increase the force and the mass at the same time, so any change in acceleration could not be put down to the force alone. Moving masses keeps the total mass a controlled variable at 0.85 kg, which makes the investigation valid. (c) Gradient $= (1.13 - 0.19) \div (1.00 - 0.20) = 1.18$ kg^{-1}. Since $a = F/m$, the gradient is $1/m$, so $m = 1 \div 1.18 = 0.85$ kg, in agreement with the 0.85 kg used. The line meets the force axis at about 0.03 N rather than at the origin. About 0.03 N of each force is used against friction in the wheels and the pulley, so the net force is slightly less than the hanging weight. Tilting the track slightly to compensate for friction would remove this systematic error.

QUESTION 25 · 3 MARKS

- (a) 1 mark: $a = 30 \div 10 = 3.0$ m/s^2.
- (b) 1 mark: the only horizontal force on B is the push from A: $F = 4.0 \times 3.0 = 12$ N.
- (c) 1 mark: the force between the boxes must now accelerate the 6.0 kg box A at the same 3.0 m/s^2, so it is $6.0 \times 3.0 = 18$ N: the box being pushed along is heavier.

QUESTION 26 · 5 MARKS

- (a) 2 marks: three forces from the phone, labelled: weight vertically down; normal force perpendicular to the book's surface; static friction up the slope, parallel to the surface (1); arrows of sensible relative length and correct directions (1).
- (b) 1 mark: on the point of slipping, $mg\sin\theta = \mu_s mg\cos\theta$, so $\mu_s = \tan 28^\circ = 0.53$.
- (c) 2 marks: kinetic friction is less than the maximum static friction, so once sliding the component of weight down the slope exceeds friction and there is a net force down the slope (1); $a = g\sin\theta - \mu g\cos\theta = 9.8(\sin 28^\circ - 0.40\cos 28^\circ) = 1.1$ m/s^2 down the slope (1).

QUESTION 27 · 3 MARKS

- (a) 1 mark: $W = Fs\cos\theta = 60 \times 15 \times \cos 30^\circ = 780$ J (779 J).
- (b) 2 marks: work done by the resistive force $= -40 \times 15 = -600$ J, so $\Delta KE = 779 - 600 = 179$ J (1); $v = \sqrt{2 \times 179 \div 20} = 4.2$ m/s (1).

Common error

Using the whole 60 N. Only the component parallel to the motion, $F\cos\theta$, does work. The vertical component pushes the trolley into the ground and does no work, because there is no motion in that direction.

QUESTION 28 · 4 MARKS

- (a) 2 marks: total momentum before is zero, so $0 = 0.80 \times 0.60 + 1.2v$ (1); $v = -0.40$ m/s, that is 0.40 m/s in the direction opposite to Q (1).
- (b) 2 marks: no net external force acts horizontally (the track is low friction), and the spring pushes on the two trolleys with equal and opposite forces for the same time, so their changes in momentum are equal and opposite and the total stays zero (1); kinetic energy is not conserved because the elastic potential energy stored in the compressed spring is transformed into kinetic energy, 0.24 J in total here (1).

QUESTION 29 · 4 MARKS

- (a) 2 marks: simulation 1 is a transverse wave: the particles oscillate at right angles to the direction of energy transfer (1); simulation 2 is a longitudinal wave: the particles oscillate parallel to the direction of energy transfer (1).
- (b) 2 marks: the particles of the medium only oscillate about fixed rest positions and are not carried along with the wave (1); the energy is passed from particle to particle, so a wave transfers energy from one place to another without transferring the medium (1).

QUESTION 30 · 4 MARKS

- (a) 1 mark: amplitude 5.0 cm (0.050 m); wavelength 1.6 m.
- (b) 2 marks: $f = v/\lambda = 4.0 \div 1.6 = 2.5$ Hz (1); $T = 1/f = 0.40$ s (1).
- (c) 1 mark: downwards (towards negative displacement). The trough to the left of Q (at 1.2 m) is moving towards Q, so Q is about to move down. (Allow: shift the waveform slightly to the right and read Q's new position.)

QUESTION 31 · 5 MARKS

- (a) 2 marks: wavelength is inversely proportional to frequency: as the frequency increases the wavelength decreases (1); data: doubling the frequency from 500 to 1000 Hz halves the wavelength from 0.69 to 0.34 m, and the product $f\lambda$ is about the same for every reading (345, 338, 340, 345 and 340 m/s) (1).
- (b) 1 mark: $v = f\lambda$; the mean of the five products is 342 m/s, about 3.4×10^2 m/s.
- (c) 1 mark: raising the frequency raises the pitch (a higher note); raising the amplitude makes the sound louder at the same pitch.
- (d) 1 mark: for example, loud sound at close range can damage hearing: keep the amplitude low and limit the time at high frequencies and volumes. Or: mains powered equipment: check leads before use.

QUESTION 32 · 4 MARKS

- (a) 2 marks: $1.00 \times \sin 45^\circ = 1.49 \sin\theta_2$ (1); $\sin\theta_2 = 0.475$, so $\theta_2 = 28^\circ$ (28.3°) (1).
- (b) 1 mark: $v = c/n = 3.00 \times 10^8 \div 1.49 = 2.01 \times 10^8$ m/s.
- (c) 1 mark: the ray bends towards the normal at the top surface (about 28°), crosses the block in a straight line, and leaves the bottom surface bent away from the normal at 45°, parallel to the original ray but shifted sideways.

QUESTION 33 · 3 MARKS

- (a) 2 marks: observer moving towards the source, so $v_{observer} = +8.0$ m/s and $v_{source} = 0$ (1); $f' = 1200 \times (340 + 8.0) \div 340 = 1230$ Hz (1.23×10^3 Hz) (1).
- (b) 1 mark: moving away, the cyclist meets the wavefronts less often, so the frequency drops suddenly as she passes, to $1200 \times 332 \div 340 = 1170$ Hz: lower than 1200 Hz.

QUESTION 34 · 2 MARKS

- 1 mark for a correct use; 1 mark for linking a property to it.
- Answers may include: thermal imaging cameras, because warm objects emit infrared and hotter objects emit more; remote controls, because infrared is invisible, cheap to produce with an LED and does not pass through walls, so it stays in one room; heat lamps and grills, because infrared is strongly absorbed by skin and food and raises their temperature.

QUESTION 35 · 3 MARKS

- (a) 1 mark: friction transfers electrons from the wool to the rubber, which holds electrons more strongly; the balloon gains extra electrons and the jumper is left positive.
- (b) 2 marks: the balloon's charge repels electrons in the wall's surface molecules slightly away, so the surface nearest the balloon becomes slightly positive (charge separation by induction, or polarisation) (1); the positive region is closer than the negative region, and the electrostatic force decreases with distance, so the attraction is larger than the repulsion and there is a net attraction (1).

QUESTION 36 · 3 MARKS

- (a) 2 marks: lines start on +q and end on −q, symmetric, with arrows from positive to negative (1); lines never cross, are closest together near the charges and between them, and some curve out around the outside (1).
- (b) 1 mark: $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} = 8.99 \times 10^9 \times 4.0 \times 10^{-6} \div 0.30^2 = 4.0 \times 10^5$ N/C, directed away from the charge.

QUESTION 37 · 2 MARKS

- 2 marks: shows a similarity and a difference: in both, energy is carried to the load by charges in a circuit (1); in DC the charge flows in one direction only with a constant voltage (12 V for a car battery), while in AC the current reverses direction many times a second as the voltage alternates (in Australia, 50 Hz at a nominal 230 V) (1).

QUESTION 38 · 5 MARKS

- (a) 1 mark: X is ohmic: its graph is a straight line through the origin, so $I \propto V$ and its resistance is constant.
- (b) 2 marks: at 2.0 V, $I = 0.16$ A, $R = 2.0 \div 0.16 = 13\ \Omega$ (12.5 Ω) (1); at 6.0 V, $I = 0.28$ A, $R = 6.0 \div 0.28 = 21\ \Omega$ (1). Accept readings within 0.01 A.
- (c) 1 mark: a larger current heats the filament; the metal ions vibrate more, so the electrons collide with them more often and the resistance increases.
- (d) 1 mark: resistance is $R = V/I$, the ratio of the values at that point, not the gradient. (The gradient of an I against V graph would give $\Delta I/\Delta V$, and only for an ohmic conductor is it the same as $1/R$.)

QUESTION 39 · 4 MARKS

- (a) 1 mark: $\frac{1}{R_p} = \frac{1}{6.0} + \frac{1}{12}$, $R_p = 4.0\ \Omega$; total $4.0 + 4.0 = 8.0\ \Omega$.
- (b) 2 marks: total current $12 \div 8.0 = 1.5$ A, and the voltage across the parallel section is $1.5 \times 4.0 = 6.0$ V (1); $I_2 = 6.0 \div 6.0 = 1.0$ A (1).
- (c) 1 mark: $I_3 = 6.0 \div 12 = 0.50$ A; $P = I^2R = 0.50^2 \times 12 = 3.0$ W.

QUESTION 40 · 2 MARKS

- 1 mark: the ammeter is connected in series with R_3 (in its branch), because it must carry the same current as R_3; it has a very low resistance so it does not reduce the current it measures.
- 1 mark: the voltmeter is connected in parallel across R_3, because it compares the energy per coulomb at the two ends of R_3; it has a very high resistance so it draws almost no current and does not change the circuit.

QUESTION 41 · 7 MARKS

MARKS	CRITERIA
6 to 7	Calculates the field correctly; explains the effect of the core; describes the relationship with data and gives a plausible reason for the last result; assesses validity and reliability separately with an improvement for each
4 to 5	Calculates the field and describes the relationship, with a partial assessment
2 to 3	Correct substitution into the solenoid formula, or a correct trend with some explanation
1	Some relevant information

- (a) 2 marks: $B = \frac{\mu_0 NI}{L} = \frac{4\pi \times 10^{-7} \times 120 \times 2.0}{0.060}$ (1); $B = 5.0 \times 10^{-3}$ T (1).
- (b) 1 mark: iron has a high magnetic permeability: the coil's field magnetises the iron, and the iron's own field adds to the coil's field, making it many times stronger.
- (c) 2 marks: as current increases the number of clips increases roughly in proportion, about 7 clips per ampere up to 2.0 A (1); at 2.5 A the increase is smaller, which could be because the iron is approaching saturation, or because the coil heated, its resistance rose and the current fell below 2.5 A; with single trials it could also be random error (1).
- (d) 2 marks: validity is limited because clips are whole numbers, can hang in chains and may become magnetised themselves, so the count does not measure field strength directly; measuring B at a fixed point with a magnetic field sensor would be more valid (1); reliability is limited because each current was tested once; repeat each reading at least three times, demagnetise the clips and let the coil cool between readings, then use the mean (1).

4.3 Where each item sits in the syllabus

QUESTIONS	FOCUS AREA AND CONTENT	OUTCOMES	TOPIC NOTES
1, 2, 21	Mechanics: scalars and vectors; distance and displacement; vectors in two dimensions; average velocity	PY-11-01	Mechanics 2

QUESTIONS	FOCUS AREA AND CONTENT	OUTCOMES	TOPIC NOTES
3, 4, 22	Mechanics: constructing and analysing motion graphs; uniformly accelerated motion	PY-11-01, PY-11WS-04	Mechanics 3.1 to 3.4
23	Mechanics: relative velocity in two dimensions	PY-11-01	Mechanics 3.6
5, 6, 7, 25	Mechanics: Newton's three laws; connected bodies in contact	PY-11-01	Mechanics 4.3 to 4.8
24	Mechanics: mandatory investigation, force, mass and acceleration	PY-11-01, PY-11WS-02, PY-11WS-05	Mechanics 4.5
26	Mechanics: static and kinetic friction; inclined planes	PY-11-01	Mechanics 4.9, 5.1 to 5.4
8, 27	Mechanics: work and kinetic energy; conservation of mechanical energy	PY-11-01	Mechanics 6.3 to 6.5
28	Mechanics: conservation of momentum; when kinetic energy is not conserved	PY-11-01	Mechanics 6.7 to 6.10
9, 10, 29, 30	Waves: wave properties; mandatory investigation, modelling transverse and longitudinal waves (by simulation); wave graphs	PY-11-02	Waves 2
11, 31	Waves: mechanical waves need a medium; mandatory investigation, wavelength, frequency, pitch and loudness	PY-11-02, PY-11WS-03	Waves 3.1 to 3.3
12, 34	Waves: the electromagnetic spectrum, $E = hf$, uses of its regions	PY-11-02	Waves 3.7, 3.8
13, 14, 32	Waves: reflection (including the Gundungurra example); refractive index; law of refraction; ray diagrams	PY-11-02	Waves 4.1, 4.4, 4.5, 4.7
33	Waves: frequency shift phenomenon for sound	PY-11-02	Waves 5.7
15, 35	Electricity and magnetism: charging by friction and induction	PY-11-03	E and M 2.1, 2.2
16, 36	Electricity and magnetism: field lines; field of a point charge; $\vec{F} = q\vec{E}$	PY-11-03	E and M 2.3 to 2.7
17, 18, 37	Electricity and magnetism: current; AC and DC; power	PY-11-03	E and M 4.1 to 4.4, 5.3
38	Electricity and magnetism: mandatory investigation, ohmic and non-ohmic conductors; factors affecting resistance	PY-11-03, PY-11WS-05	E and M 4.5, 4.6
19, 39, 40	Electricity and magnetism: series, parallel and combination circuits; meters	PY-11-03	E and M 6
20, 41	Electricity and magnetism: field of a wire and a solenoid; mandatory investigation, strength of an electromagnet	PY-11-03, PY-11WS-05	E and M 7

4.4 What to do with your mark

IF YOU LOST MARKS ON	GO TO
Questions 21 to 23	Mechanics Topic Notes 2 and 3: draw the vector diagram before you calculate
Questions 24 to 28	Mechanics Topic Notes 4 to 6: start every force question with a free-body diagram
Questions 29 to 34	Waves Topic Notes 2 to 5: state what stays fixed (frequency) before you change anything
Questions 35 to 41	Electricity and magnetism Topic Notes 2, 4, 6 and 7, and the Exemplar Response on circuits
The data and investigation items (22, 24, 31, 38, 41)	The Working scientifically and investigations Guide: variables, lines of best fit, validity and reliability

Attempt record

Come back every few weeks and date it. Improvement is invisible from the inside, which is why students who are getting better so often believe they are not.

DATE	MARK OUT OF 100	THE ONE THING TO FIX NEXT TIME

Fill one row every time you sit a set. A tracker with three rows in it is worth more than a perfect one you never started, because the pattern you are looking for only shows up across attempts, not inside one.

About this resource

MA99 EDUCATION

Scope

NSW Physics, Year 11. Written to the NSW Physics 11-12 Syllabus 2025, all Year 11 focus areas, for students sitting the HSC in 2028 and later years. Written to the new syllabus, taught in Year 11 from 2027. Every value in a worked example was recomputed from its inputs before printing; contexts are invented unless a source is named.

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