AEO «Nazarbayev Intellectual Schools»
Center for Pedagogical Measurements

NIS
Nazarbayev
Intellectual
Schools

EXTERNAL SUMMATIVE ASSESSMENT
TEST SPECIFICATION
«PHYSICS»

Grade 12

Астана, 2024

Contents

1 Purpose

The purpose of assessment is to identify learners' knowledge and abilities acquired in the process of learning as well as their abilities to apply high order thinking skills.

1.1 Relationship with International Standards

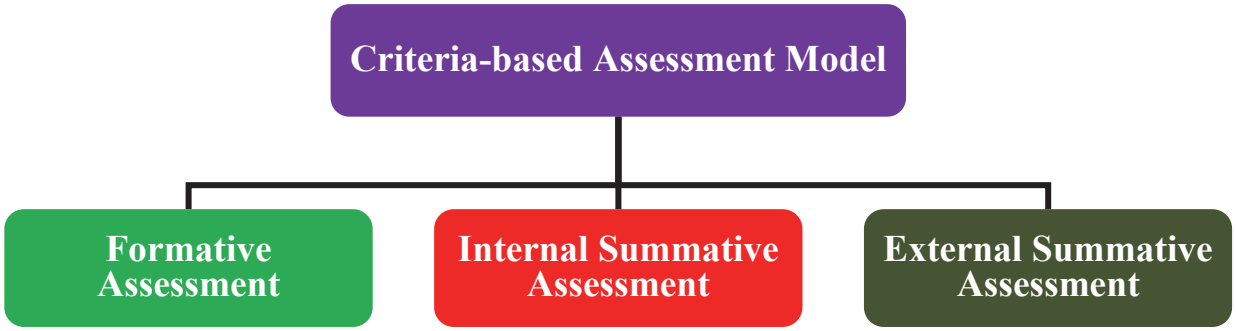
The Grade 12 Physics External Summative Assessment is designed to be comparable to the Cambridge International A-Level standard.

1.2 Relationship with Subject Programme

The Grade 12 External Summative Assessment will assess the content of AEO «Nazarbayev Intellectual Schools» Educational Programme – NIS-Programme for Grade 11 and Grade 12. The level of knowledge and abilities, as well as skills, will be defined by the expected outcomes within the Physics Subject Programme.

1.3 Relationship with the Criteria-based Assessment Model (CBAM)

The External Summative Assessment forms one part of the *Criteria-based Assessment Model* which also consists of Formative Assessment and Internal Summative Assessment.



2 External Summative Assessment overview

Paper 1	**60 minutes**
All questions are compulsory. Learners answer 40 multiple-choice questions. Each question will have four options, from which learners will choose correct one. The questions will assess the learners' knowledge, understanding, and their ability of applying and evaluating information. Calculators are allowed.	
40 marks are 23% of total amount of marks	
Paper 2	**120 minutes**
All questions are compulsory. Learners answer between 8 and 12 questions, which may be broken into subparts. The questions will assess the learners' knowledge and their ability of handling, applying and evaluating information. Calculators are allowed.	
100 marks are 59% of total amount of marks	

Paper 3	**90 minutes**
All questions are compulsory. This paper consists of two or three theoretical experiments. The experiments will assess the learners' knowledge, their practical skills of planning, analysis and evaluation. Calculators are allowed.	
30 marks are 18% of total amount of marks	

2.1 Assessment objectives

AO1	**Knowledge with Understanding** Learners should be able to demonstrate knowledge and understanding in relation to: • scientific phenomena, facts, laws, definitions, concepts and theories; • scientific vocabulary, terminology and conventions (including symbols, quantities and units); • operating principle of scientific instruments and apparatus, including techniques of operation and aspects of safety; • scientific quantities and their determination; • scientific and technological applications with their social, economic and environmental implications; • presenting reasoned explanations for phenomena, patterns and relationships.
AO2	**Handling, Applying and Evaluating Information** Learners should be able to: • locate, select, organise and present information from a variety of sources; • translate information from one form to another; • manipulate numerical and other data; • analyse and evaluate information to identify patterns, report trends and draw conclusions; • make predictions and put forward hypotheses; • find arguments in support of hypotheses or to assess the course of action; • apply knowledge, including principles, to new situations; • evaluate information and hypotheses; • demonstrate an awareness of the limitations of physical theories and models.
AO3	**Experimental Skills and Investigations** Learners should be able to: • Identify a problem; design and plan investigations; • Identify independent, dependent and controlled variables; • Analyse and process data. • Interpret and evaluate observations and experimental data; • Make conclusions based on evidence obtained from an investigation.

2.2 Use of calculators

Scientific calculators are allowed in all papers.

Calculators must be:
- of a size suitable for use on the desk;
- either battery or solar powered;
- free of lids, cases and covers which have printed instructions or formulas.

Calculators must not contain any of these facilities:
- symbolic algebra manipulation;
- symbolic differentiation or integration;
- communication with other machines or the internet.

Calculators may not contain any retrievable information including:
- databanks;
- dictionaries;
- mathematical formulas;
- text.

2.3 Formulae and Data

Formulae and data will be provided in Papers 1-3.

3 Description of papers

All learners complete all 3 papers. Papers 1 and 2 will require demonstrating knowledge and understanding of physics, ability of handling, applying and evaluating information (in accordance with AO1 and AO2). Paper 3 will assess learners' practical and experimental skills (in accordance with AO2 and AO3).

3.1 Paper 1

60 minutes

Calculators are allowed to use.
Paper 1 consists of 40 multiple-choice questions with one correct option.
All questions are compulsory.
Total 40 marks.

3.2 Paper 2

120 minutes

Calculators are allowed to use.
Paper 2 consists of 8-12 structured questions, which require short or detailed answers.
Learners may use ruler, pencil, eraser.
All questions are compulsory.
Total 100 marks.

3.3 Paper 3

90 minutes

Calculators are allowed to use.
Learners may use ruler, pencil, eraser.
Paper 3 consists of structured questions related to two or three theoretical experiments.
All questions are compulsory.
Total 30 marks.

3.4 Balance of marks

The balance of marks for the assessment objectives is shown in the table below:

Assessment Objectives	Paper 1	Paper 2	Paper 3	TOTAL
AO1	16	40	0	**56**
AO2	24	60	6	**90**
AO3	0	0	24	**24**
Total	**40**	**100**	**30**	**170**

3.5 Language of assessment

The language of assessment is English.

4 Administration

All assessments must be conducted in compliance with all security measures in accordance with Instruction on the organisation and administration of External Summative Assessment of learning achievements of learners of Nazarbayev Intellectual schools. The instruction contains the following main points:

- examination materials and their security;
- responsibilities of teachers, invigilators and administrators;
- setting up examination rooms, material required for administering examinations;
- appropriate venues for conducting written examinations.

5 The Marking process

Marking is carried out by the Attestation committee, which includes the Principal Examiner, Team Leaders and Examiners. To mark each examination work, groups of Examiners are formed, led by Team Leaders.

During the marking, all Examiners use the same version of the mark scheme. The Principal Examiner and the Team Leaders check selectively papers marked by Examiners to ensure the correct application of the Mark Scheme and the objectivity of the evaluation.

6 The grading process

The results of the assessment will be reported in the form of a grades A*, A, B, C, D and E, where A* is the highest grade and E is the lowest passing grade.

Grade U ('ungraded') will not represent a pass in a syllabus.

A learner's syllabus Grade will be calculated directly from the total of their marks on the components that they took (weighted in accordance with the set specifications), not from the component Grades.

The test specification contains A, C, and E Grades descriptors. The Attestation committee sets the thresholds for these grades based on professional judgment and the results of learners. The thresholds of the grades A *, B and D are established by arithmetic means.

Grades A *, A, B, C, D and E are transferred into the final grades.

6.1 Grade descriptions

Key Grade Descriptions are provided to give a general indication of the standards of achievement likely to have been shown by learners awarded particular grades. The grade awarded will depend in practice upon the extent to which the learner has met the assessment objectives overall.

Grade	Grade Description
A	Demonstrates a wide and detailed knowledge of the subject, and has a clear understanding of the principles and methods of subject. The principles can be applied in both familiar and unfamiliar situations. Has a good ability to evaluate hypotheses. Answers given are well-expressed, direct and relevant, and complex calculations are accurate and correctly set out. Solves problems in situations involving a wide range of variables. Is able to generate a hypothesis to explain theories and phenomena. Can design and plan investigations using suitable methods, interprets and evaluates observations and experimental data, can evaluate and suggest improvements to ensure precision and accuracy.
C	Demonstrates a sound knowledge in many areas of the subject with some omissions, and has an understanding of many principles and methods of subject. The principles can be applied most effectively in familiar and occasionally unfamiliar situations. Has a reasonable ability to evaluate information and hypotheses. Answers given are often well-expressed, relevant and calculations frequently produce the correct answer. Solves problems involving with a limited range of variables. Is able to generate a simple hypothesis to test a theory and make a prediction. Can generate a simple hypothesis to explain a given set of facts and data. Is able to plan a scientific task, to test an idea, present evidence.
E	Demonstrates a basic knowledge of the simple areas of the subject with some important omissions, and has a limited understanding of the principles and methods of subject. The principles are generally only applied effectively in familiar situations. Has some ability to evaluate information and hypotheses. Answers given often include relevant points but can be confused with irrelevant additions. Can solve a problem involving one step where only a minor manipulation of data is needed. Will recognise a hypothesis that explains a set of facts or data. Can plan a scientific task, test a basic idea, answer a simple question, or solve a straightforward problem. Can draw simple conclusions consistent with the evidence collected and present evidence as charts, tables or graphs.

7 Sample questions

At the end of each question in square brackets [1] the mark available is indicated.
As a guidance, mark schemes are provided, which clearly indicate the number of marks awarded for each question.

Instruction on marking Physics:

M mark is awarded for applying the correct method and is not deducted for arithmetic errors;

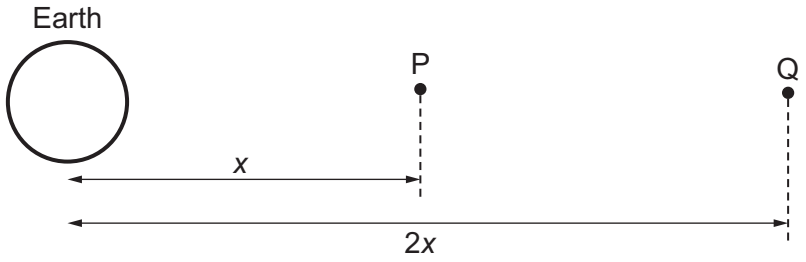
A mark is awarded for the correct answer and depends on the previous mark of M, so when M0, A1 is not awarded;

B mark is awarded regardless of the M mark and is awarded for the correct intermediate result or correct answer;

Ft in the mark scheme, which states "follows from ...", the mark can be added for the learner's actions, which follow from the answer to the previous question, whether it is correct or not.

7.1 Paper 1

1 Two points P and Q are at distances x and 2x from the centre of the earth.



The gravitational potential at P is $-16\,\text{MJ kg}^{-1}$.

What is the work done in taking a mass of 1.0 kg from P to Q?

A –12 MJ

B –8.0 MJ

C +8.0 MJ

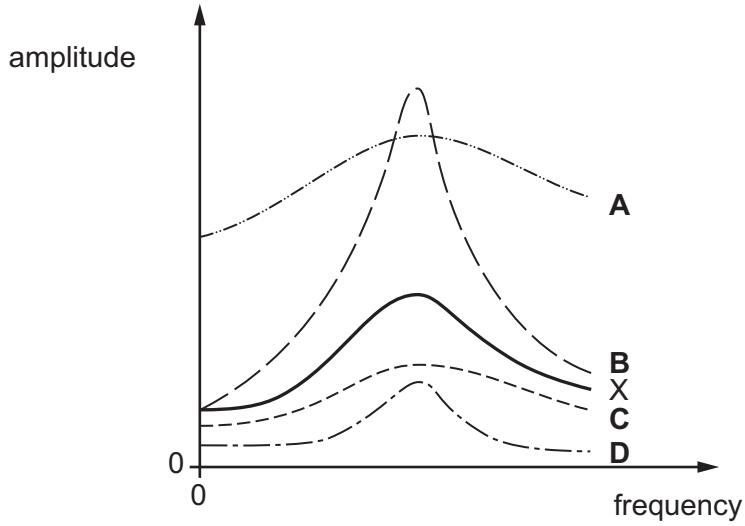
D +12 MJ

A ☐ **B** ☐ **C** ☐ **D** ☐

[1]

2 Line X shows how the amplitude of an oscillating system varies with frequency.

Which line shows the response of the system when there is **less** damping?



A ☐ **B** ☐ **C** ☐ **D** ☐

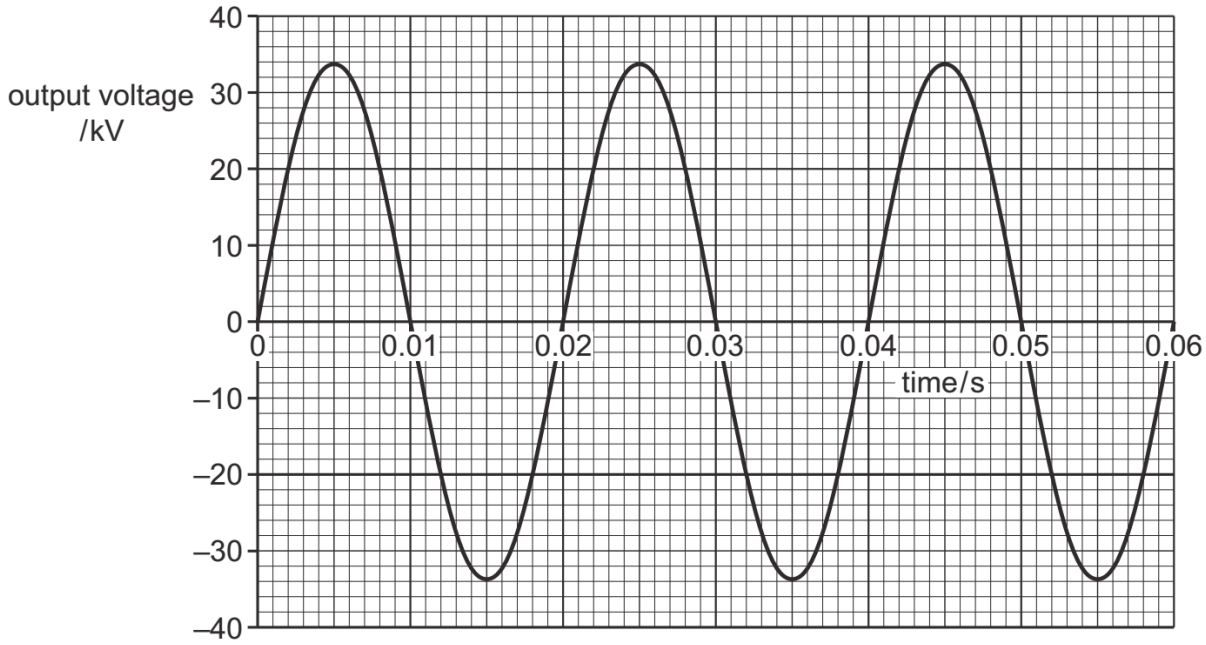
[1]

Question	Answer	Mark	Additional Guidance
1	**C**	**[1]**	
2	**B**	**[1]**	

7.2 Paper 2

1 The generator at a power station produces an alternating output voltage.

The figure below shows how the output voltage varies with time.



(a) Using the figure, determine

(i) the r.m.s. (root-mean-square) value of the output voltage,

r.m.s. voltage = ... kV [2]

(ii) the frequency of the output voltage.

frequency = ... Hz [2]

(b) The generator supplies an r.m.s. current of 19 000 A.

Calculate the power supplied in megawatts.

power = ... MW [3]

(c) (i) The output of the generator is connected to the primary coil of a transformer. The primary coil has 70 turns. The secondary coil has 1180 turns and is connected to power transmission cables.

Calculate the r.m.s. voltage output of the transformer.

r.m.s. voltage = ... kV [2]

(ii) Explain how a transformer operates.

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

2 A photoelectric cell contains sodium which is struck by ultraviolet radiation of frequency f. It emits electrons with maximum velocity v_{max}. The work function of sodium is ϕ.

(a) State the equation which relates f, ϕ and v_{max} and state what the other terms in the equation represent.

.....

.....

..... [2]

(b) When f is 1.40×10^{15} Hz, v_{max} is 1.11×10^{6} m s^{-1}.

Calculate

(i) the energy of a photon of the ultraviolet radiation,

energy = ... J [2]

(ii) the work function of sodium.

work function = ... J [2]

(c) State and explain the relationship between the number of electrons emitted per second and the intensity of the ultraviolet radiation.

.....

.....

..... [2]

(d) In a second experiment, the sodium is struck by electromagnetic radiation with a higher frequency.

Explain how this affects the electrons which are emitted.

.....

..... [1]

[Total: 9]

Question	Answer	Mark	Additional Guidance
1(a)(i)	33.5 (peak) 23.3 – 24.1 (kV)	C1 A1 **[2]**	**accept** 33.0 **or** 34.0 **accept** in volts if k crossed out
1(a)(ii)	(f =)1 ÷ 0.020 **or** 1 ÷ T 50.0 (Hz)	C1 A1 **[2]**	
1(b)	(P =)VI **or** 2.37 × 10^{N} × 1.90 × 10^{N} 2.37 × 10^{4} × 1.9 × 10^{4} **or** 23.7 × 19.0 **or** 4.50 × 10^{N} 450 (MW)	C1 C1 A1 **[3]**	**ecf (a)(i)** **ecf (a)(i)** **ecf (a)(i)** **accept** 4.5 × 108 if M is crossed out
1(c)(i)	(V_2 =)$V_1N_2 \div N_1$ **or** 23 700 × 1180 ÷ 70 400 (kV)	C1 A1 **[2]**	 **accept** 400 000 if k is crossed out
1(c)(ii)	mention of a magnetic field changing magnetic field emf / voltage, produced / induced / generated	B1 B1 B1 **[3]**	
2(a)	$hf = \phi + mv^2_{max} \div 2$ h is the Planck constant **and** m is the mass of an electron	B1 B1 **[2]**	
2(b)(i)	(E =)hf **or** 6.63 × 10^{-31} × 1.40 × 10^{15} 9.28 × 10^{-19} (J)	C1 A1 **[2]**	

2(b)(ii)	($mv^2_{max} \div 2$ =) $9.11 \times 10^{-34} \times (1.11 \times 10^6)^2 \div 2$ **or** $9.28 \times 10^{-19} - 5.61 \times 10^{-19}$ 3.67×10^{-19} (J)	C1 A1 **[2]**	
2(c)	direct proportion number of photons increases with intensity	B1 B1 **[2]**	**accept** as intensity doubles, the current doubles **accept** proportional
2(d)	photon energy and v_{max} is greater / more KE	**[1]**	

7.3 Paper 3

A spherical rigid ball is released from rest and starts rolling down an inclined plane and then falls with a parabolic trajectory and lands a distance *L* from the end.

A student wants to investigate the effect of changing the height *h* of the ball above the bench to its range along the horizontal axis.

This experiment may be performed in the laboratory by varying the height of the ball above the bench. The ball will have an initial horizontal velocity if it rolls down from an inclined track as shown in **Fig. 1.1**.

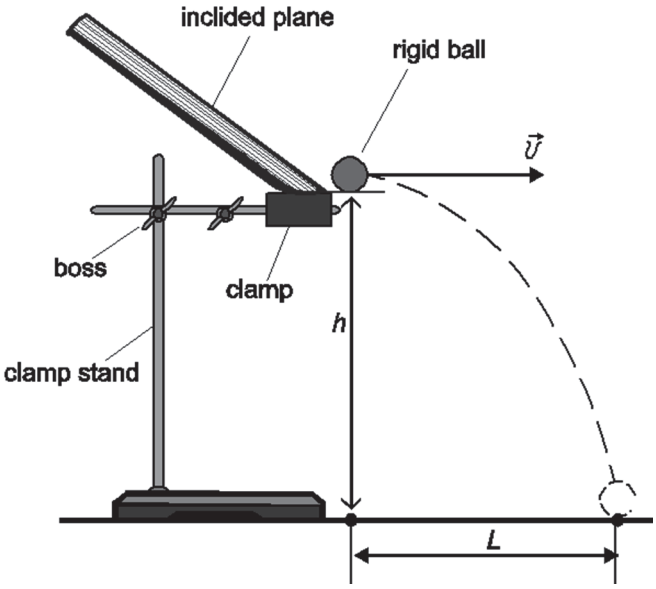


Fig.1.1

When the ball leaves the inclined track, it is suggested that the range is related to the height by the equation

$$L = v\left(\frac{2}{g}\right)^{\frac{1}{2}}\sqrt{h}$$

Where v is velocity of the ball at the end point of the inclined plane, *g* is acceleration of free fall of 9.81 ms^{-2}, *L* is range, *h* is height.

Design a laboratory experiment to determine the value of the velocity of the ball at the end point of the inclined plane. You should draw a diagram, on page 3, showing the arrangement of your equipment.

In your account, you should pay particular attention to

(a) the procedure to be followed .....

(b) the measurements to be taken .....

(c) the control of variables .....

(d) the analysis of the data .....

(e) the possible limitations and ways of improvement of experiment .....

(f) the safety precautions to be taken .....

[Total:15]

Diagram

1 Planning (15 marks)		
Criteria	**Mark**	**Additional Guidance**
Defining the problem identify the independent and dependent variables: h is the independent variable and L is the dependent variable or vary hand measure L Keep constant initial height of the ball on the inclined track Keep constant the bottom of the inclined track to parallel to the plane of the bench	**[3]**	Relevant points might include
Methods of data collection Labelled diagram of apparatus: stand with boss and clamp, inclined device, and ball. Stand on bench with clamped rule vertically to measure vertical distance. Use measured tape/ ruler to measure horizontal distance. Take minimum 4 readings of range for various height. A minimum number of repeat readings: 4	**[4]**	Relevant points might include
Method of analysis Plot a graph of L against $\sqrt{h}$. Determine gradient of the graph.($\text{gradient} = \frac{\Delta L}{\Delta\sqrt{h}}$) Determine velocity of the ball at the end point of the inclined plane $v = \frac{\sqrt{g} \cdot \boldsymbol{gradient}}{\sqrt{2}}$	**[3]**	
Limitation and improvement Uncertain position of the ball above the bench for measurement of the range Uncertain point of falling of the ball on the bench for measurement of the range Use a plumb line in appropriate position Use a thin layer of sand	**[4]**	Relevant points might include

Safety considerations **One from** Reasoned method to prevent falling of the stand Reasoned method to prevent injury from a ball hit	**[1]**	Relevant points might include
		Total 15

2 A student is investigating an electrical circuit in this experiment. The circuit is set up as shown in **Fig. 2.1**.

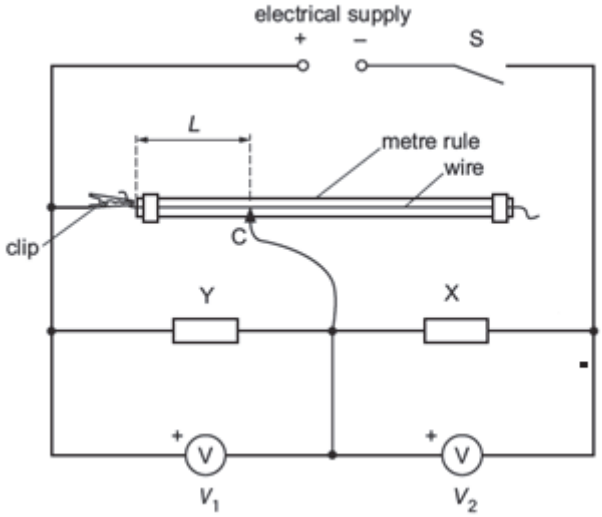


Fig. 2.1

The electrical circuit consists of DC power supply, two resistors *Y* and *X,* two voltmeters V_1 and V_2 and a metre rule with a thin wire.

The student measures voltage on resistors *Y* and *X*, with a different distance *L* each time.

It is suggested that *L,* V_1 and V_2 are related by the equation

$$\frac{V_2}{V_1} = \frac{p}{L} + q$$

where *p* and *q* are constants.

(a) A graph is plotted of $\frac{V_2}{V_1}$ on the y-axis against $\frac{1}{L}$ on the x-axis.

Determine expressions (symbols) for the gradient and the y-intercept.

gradient = ...

y-intercept = ...

[1]

(b) Values of L, V_1, V_2 are given in **Fig. 2.2**.

L/ m	σ_L / %	V_1/ V	V_2/ V	$\frac{V_2}{V_1}$	$\frac{1}{L}$
0.100		0.19	3.21		
0.250		0.38	3.03		
0.400		0.50	2.92		
0.500		0.56	2.85		
0.750		0.66	2.73		
0.900		0.72	2.71		

Fig.2.2

(i) Complete the missing units to the titles of last two columns of **Fig. 2.2**.

[1]

(ii) Calculate the percentage uncertainties of L (σ_L), if the least division of the metre rule is 0.001 m. Record values in **Fig. 2.2**.

[1]

(iii) Calculate and record values of $\frac{V_2}{V_1}$ and $\frac{1}{L}$ in **Fig. 2.2**.

[2]

(c) **(i)** Plot a graph of $\frac{V_2}{V_1}$ on the *y*-axis against $\frac{1}{L}$ on the *x*-axis.

Use the grid in **Fig. 2.3**.

[3]

(ii) Draw the straight line of the best fit for your points.

[1]

(iii) Plot a triangle on **Fig. 2.3**, for determination of the gradient.

[2]

(iv) Determine the gradient and *y*-intercept of your line. Show your work.

gradient = ...

y-intercept = ...

[2]

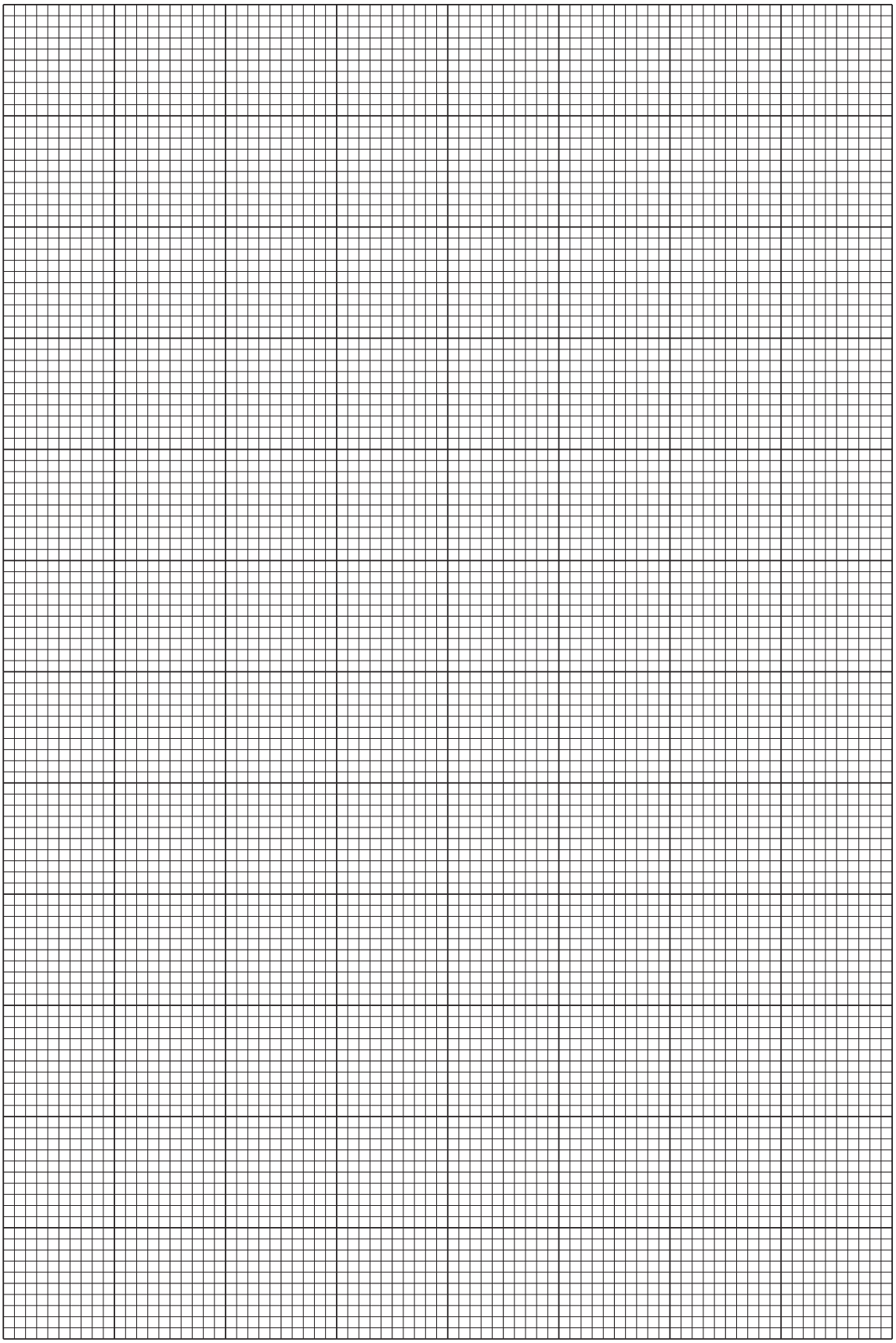


Fig 2.3

(d) Using your answers from **(c)(iv)**, determine the values of p and q and give the corresponding units.

p= .....

q= .....

[2]

[Total: 15]

Mark scheme

<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th><th>Additional Guidance</th></tr>
<tr><td>2(a)</td><td>p and q</td><td>B1
[1]</td><td></td></tr>
<tr><td>2(b)(i)</td><td>without unit and m^{-1}</td><td>B1
[1]</td><td>Accept 1/m</td></tr>
<tr><td>2(b)(ii)</td><td>1.0
0.40
0.25
0.20
0.13
0.11</td><td>B1

[1]</td><td></td></tr>
<tr><td>2(b)(iii)</td><td>calculated values of $V_2 \div V_1$ are correct

each value of $1 \div L$ has the same number of sig. figs. (or one more than) in the corresponding value of L

<table><tr><th>$\frac{V_2}{V_1}$</th><th>$\frac{1}{L}$</th></tr><tr><td>16.9</td><td>10.0</td></tr><tr><td>7.97</td><td>4.00</td></tr><tr><td>5.84</td><td>2.50</td></tr><tr><td>5.09</td><td>2.00</td></tr><tr><td>4.14</td><td>1.33</td></tr><tr><td>3.76</td><td>1.11</td></tr></table></td><td>B1

B1

[2]</td><td></td></tr>
<tr><td>2(c)(i)</td><td>axes are labelled with quantity and unit and are not reversed

appropriate choice of scales, so that points occupy at least six of the vertical 2 cm squares and four horizontal 2 cm squares

all points from the table are plotted accurately using suitable marks</td><td>B1

B1

B1

[3]</td><td>

do not accept awkward scales such as 3:10

any coordinates used are accurate to half a small

points must be in the grid area, with positions accurate to half a small square</td></tr>
<tr><td>2(c)(ii)</td><td>suitable straight line drawn through points</td><td>B1
[1]</td><td>accept if one point is ignored</td></tr>
</table>

2(c)(iii)	Gradient triangle is drawing correctly: using points from the best fit line at least half the line length apart the triangle's points are not from the table in Fig. 2.2	B1 B1 **[2]**	
2(c)(iv)	gradient correctly calculated (ignoring any unit) = 1.8–2.2 m intercept correctly determined (ignoring any unit) = 2–2.4	B1 B1 **[2]**	
2(d)	p = gradient value **and** q = intercept value unit of p – m unit of q – no unit	B1 B1 **[2]**	
			Total 15