Senior Physics Challenge Task 1

ANSWER BOOKLET

Part 1: Experimental Setup [9 marks]

Suggest a suitable method for slowly varying the temperature of the silicon diode.

Current: determine

- the numerical value for current
- the resolution of the ammeter
- the percentage uncertainty on the measurement of current

Potential Difference: determine

- the numerical value for potential difference
- the resolution of the voltmeter
- the percentage uncertainty on the measurement of potential difference

Temperature: determine

- the numerical value for temperature in Kelvin

- the resolution of the thermometer

- the percentage uncertainty on the measurement of Kelvin temperature

Note: Temperature values should be given in Kelvin.

Part 2: Data Analysis [9 marks]

Sketch a graph of the experimental data using the axes in figure 1. Label the axes. Do not plot each data point, simply sketch the expected shape of a graph of forward current against temperature.

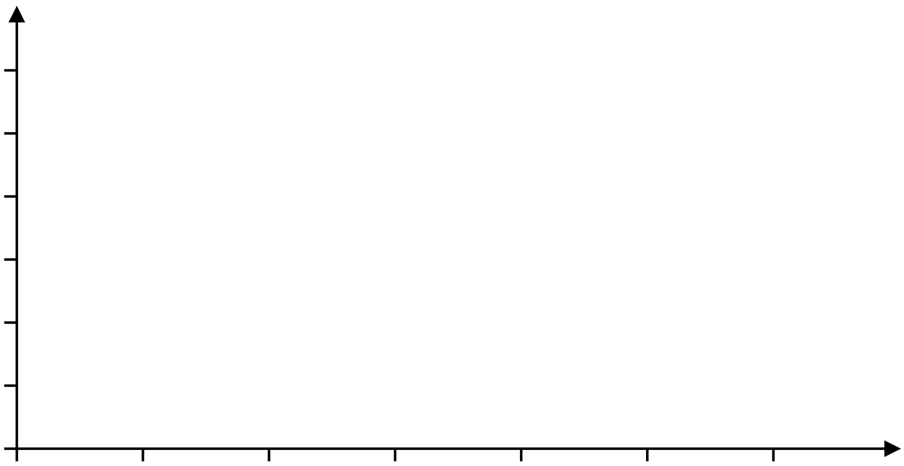


Figure 1: Sketch of experiment data

Explain why the graph you have sketched does not allow for the numerical constants in the relationship between temperature and current to be conveniently calculated.

Add calculated values to table 1. Include appropriate column headings and units.

Temperature / °C	Forward current / mA			
5	0.8			
10	1.2			
15	1.8			
20	2.5			
25	4.0			
30	5.8			
35	8.3			
40	12.0			
45	20.0			
50	23.0			
55	32.0			
60	40.0			
65	55.0			

Table 1: Experimental data for a silicon diode

Explain how a numerical value for the dimensionless constant n can be determined from the graph of $\ln(I_f)$ against $\frac{1}{T}$.

Part 3: Graphical Analysis [7 marks]

Plot a graph of $\ln(I_f)$ against $\dfrac{1}{T}$ and draw a line of best fit.

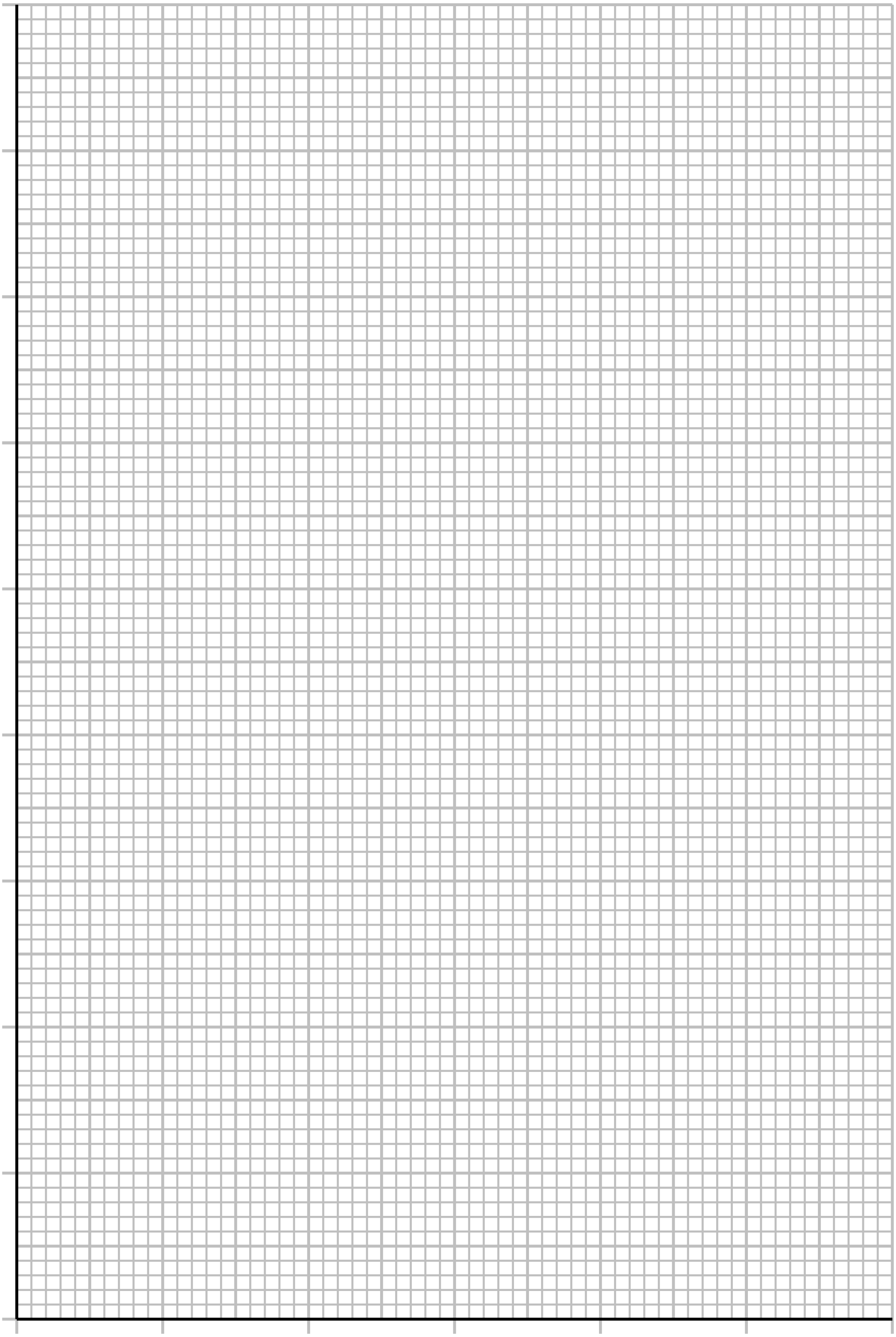


Figure 2: Plot of transformed experiment data

Part 4: Numerical Analysis [7 marks]

Calculate the gradient of your line of best fit for the graph plotted in figure 2.

Calculate the numerical value of the dimensionless constant, n.

Part 5: Diode Investigation [8 marks]

Record the values of the resistors used, the combined resistance, R_{total}, the measurements of potential differences and the calculated value of the current in table 2.

Resistors used	R_{total} / kΩ	V_R / V	V_f / V	Current / mA
2.2 kΩ	2.2 kΩ			

Table 2: Experimental data for a silicon diode.

Plot the values of current and potential difference across the diode (V_f) on the grid in figure 3.

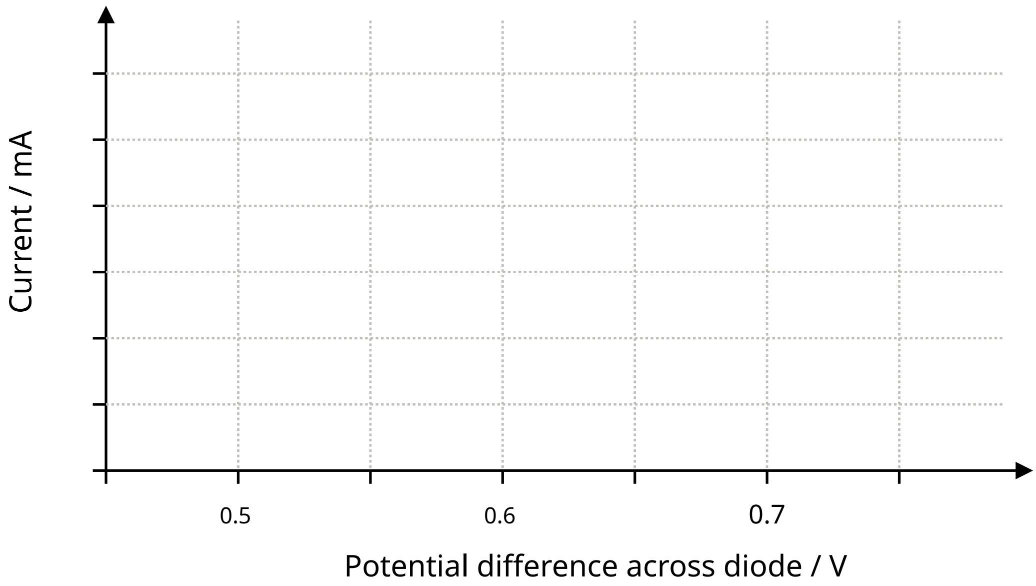


Figure 3: Current against potential difference (V_f) for a diode

Discuss to what extent your measurements in part 5 support the idea that the diode is of the same type, and has the same characteristics, as the diode used to obtain the data used in part 2.

Senior Physics Challenge Task 2

ANSWER BOOKLET

Record the mass of the beaker.

Part 1: Mass of the Ruler [6 marks]

Record your measured value for the centre of mass of the ruler.

Record the measured values in the table.

Mass of beaker and water / grams	x / cm	y / cm	Mass of ruler / grams

Table 1: Results – mass of a 1 m ruler.

Calculate the mass of the ruler for each set of results. Complete the final column in the table.

Calculate the average mass of the ruler.

Part 2: Dimensions of the Ruler [4 marks]

Using the vernier calipers, **determine** the width (a) of the ruler.

Using the vernier calipers, **determine** the thickness (b) of the ruler.

State the absolute uncertainty on your values of a and b.

Suggest one measurement technique that can be used to improve the measurement of a and b.

Part 3: Period of Oscillation [7 marks]

Record the experimental data in the table. Use some or all of the rows available.

Column headings:

$T1_{10}$ is the first time for 10 oscillations
$T2_{10}$ is the second time for 10 oscillations
Av T_{10} is the average time for 10 oscillations
T_{average} is the average time for 1 oscillation

M / kg	$T1_{10}$ / s	$T2_{10}$ / s	Av T_{10} / s	T_{average} / s	T^2 / s^2

Table 2: Experimental data: Time period vs Mass

Calculate the average time for 10 oscillations

Calculate the average time, T, for one oscillation

Complete the T^2 column in the table

Part 4: Graphical Analysis [7 marks]

Plot a graph of T^2 on the y-axis against M on the x-axis and **add** a best fit line.

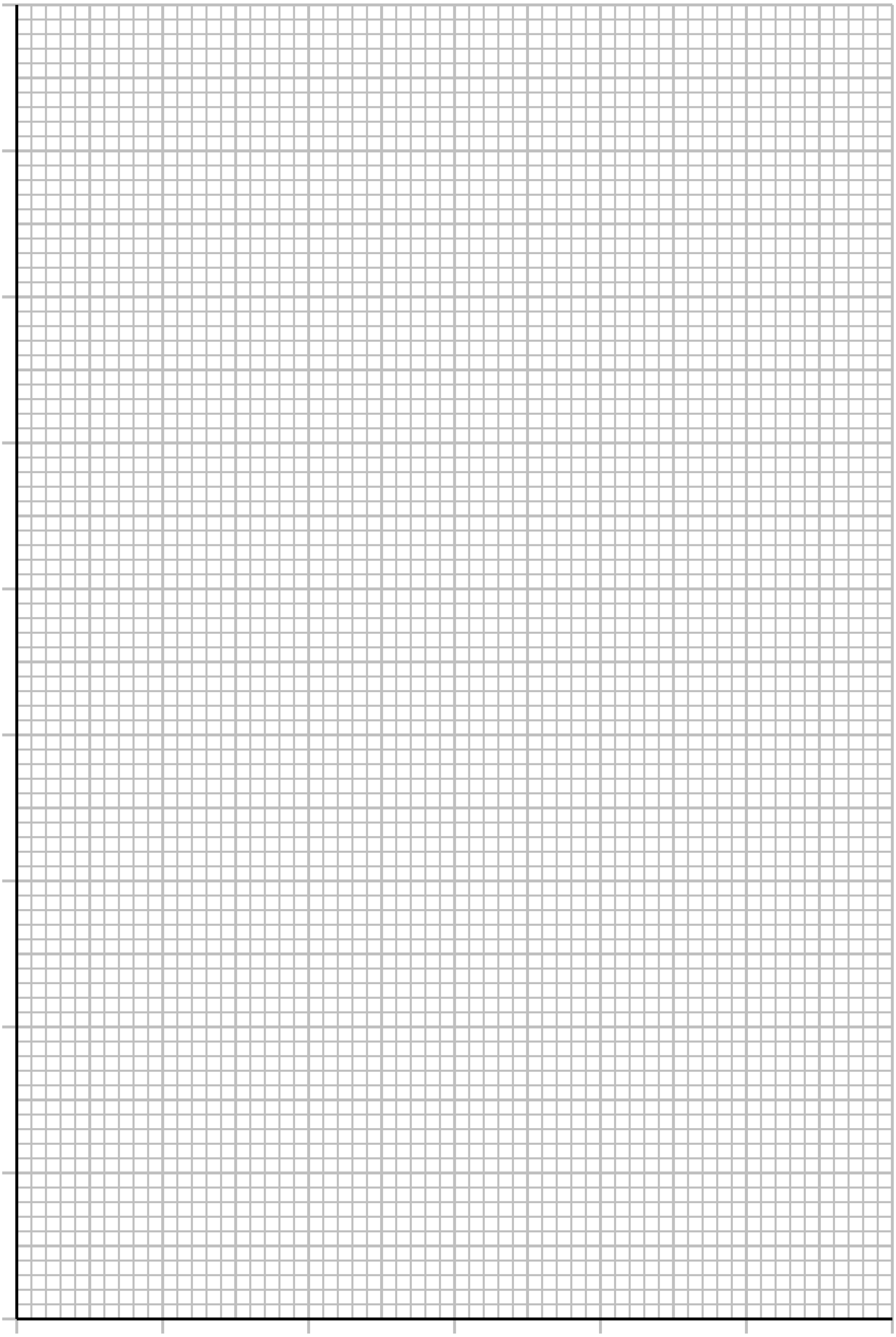


Figure 1: Graph of T^2 against M

Part 5: Numerical Analysis [6 marks]

Calculate the gradient of the best fit line

Knowing numerical values for L, a and b, **determine** the Young's modulus of the cantilever (ruler).

Knowing the mass of the ruler from part 1, **determine** the mass, m, of the section of ruler of length L. Show your working.

Determine the y-intercept from the graph. Knowing numerical values for the gradient, y-intercept and m, **determine** a numerical value of the dimensionless constant, α.

Compare your value of α with the accepted value for a uniform cantilever of $\alpha = 0.24$ and **comment** on any discrepancy.

Senior Physics Challenge Task 3

ANSWER BOOKLET

Part 1: Observations [8 marks]

Observing the action of a single polaroid filter

Describe your observations carefully and fully.

Observing the action of a pair of polaroid filters

Describe your observations carefully and fully.

Observing reflections through a polaroid filter

Describe your observations carefully and fully.

Observing a transparent material through polaroid filters

Describe your observations carefully and fully.

Part 2: Light Intensity vs Angle [8 marks]

Testing the LDR

Record the resistance of the LDR.

Determine the illuminance, **show** your working

Method

Record the offset angle.

Record the experimental data in table 1. Use some or all of the rows.

Corrected angle θ / degrees	Resistance / Ω	$\cos^2(\theta)$	Illuminance (I) / lux

Table 1: Experimental data and calculated values

Calculate $\cos^2(\theta)$ for each set of data in table 1. **Record** the calculated values in the third column of the table.

Use the resistance values recorded in table 1 and the calibration graph, or the associated log–log equation, to **calculate** the illuminance. **Record** the calculated values in the final column of the table.

Part 3: Graphical Analysis [7 marks]

Plot a graph of illuminance (I) on the y-axis against $\cos^2(\theta)$ on the x-axis. **Add** a best fit line.

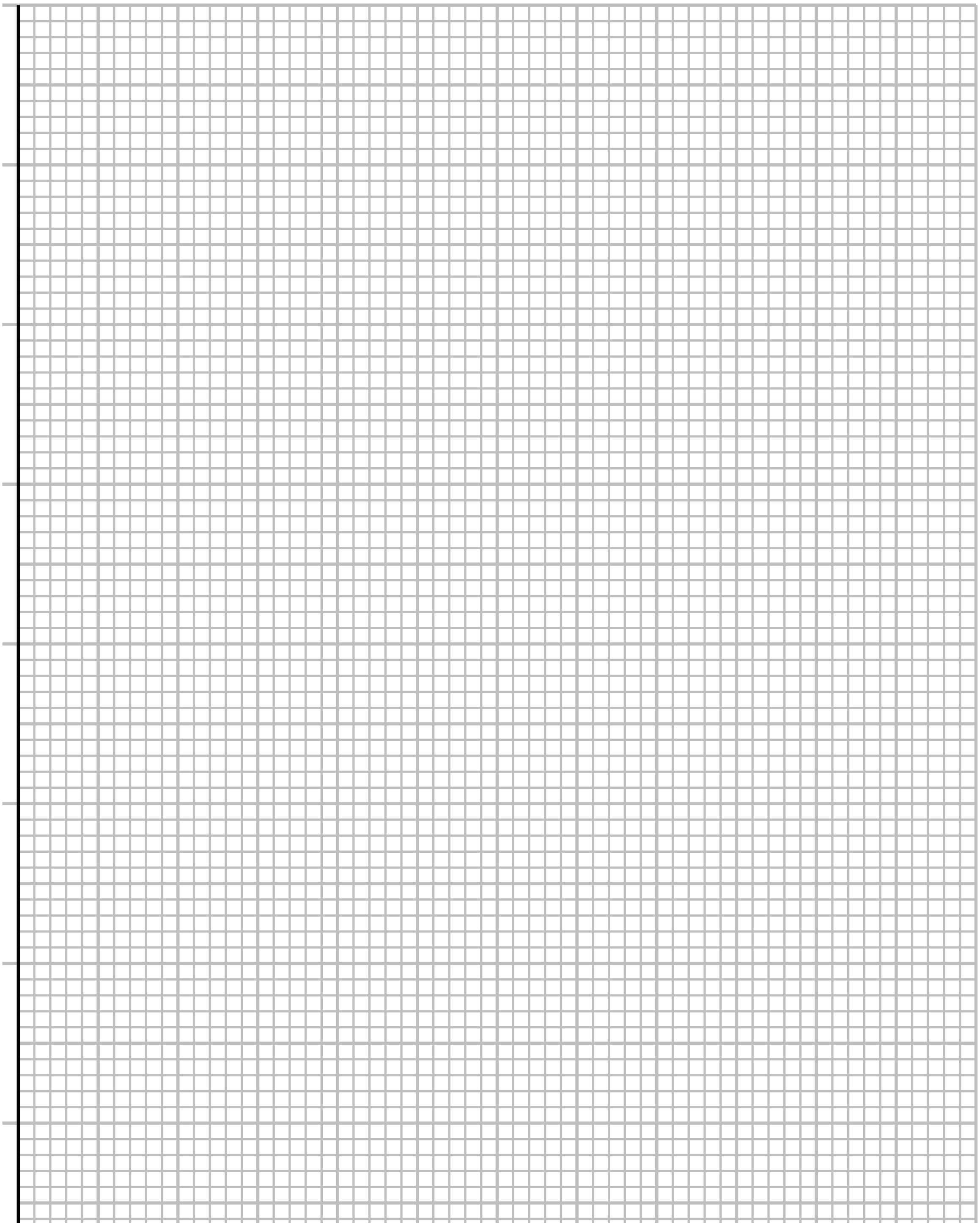


Figure 1: Graph of illuminance (I) against $\cos^2(\theta)$

Part 4: Malus's Law [7 marks]

Determine the gradient of the best fit line.

Remove the polaroids and record the resistance reading on the multimeter.

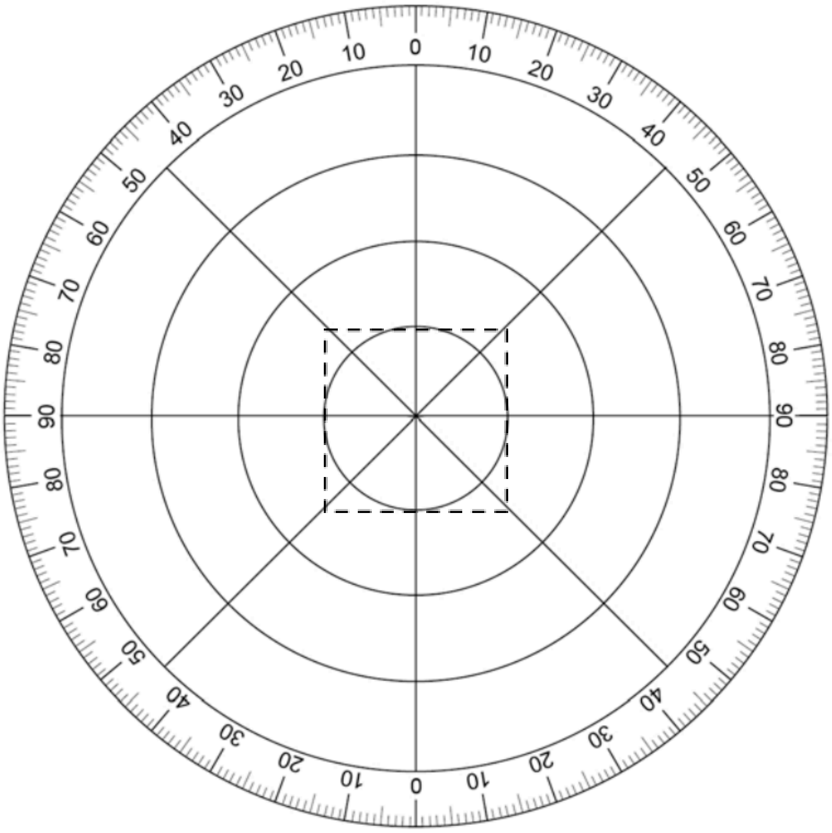
Determine the illuminance with no polaroids in place.

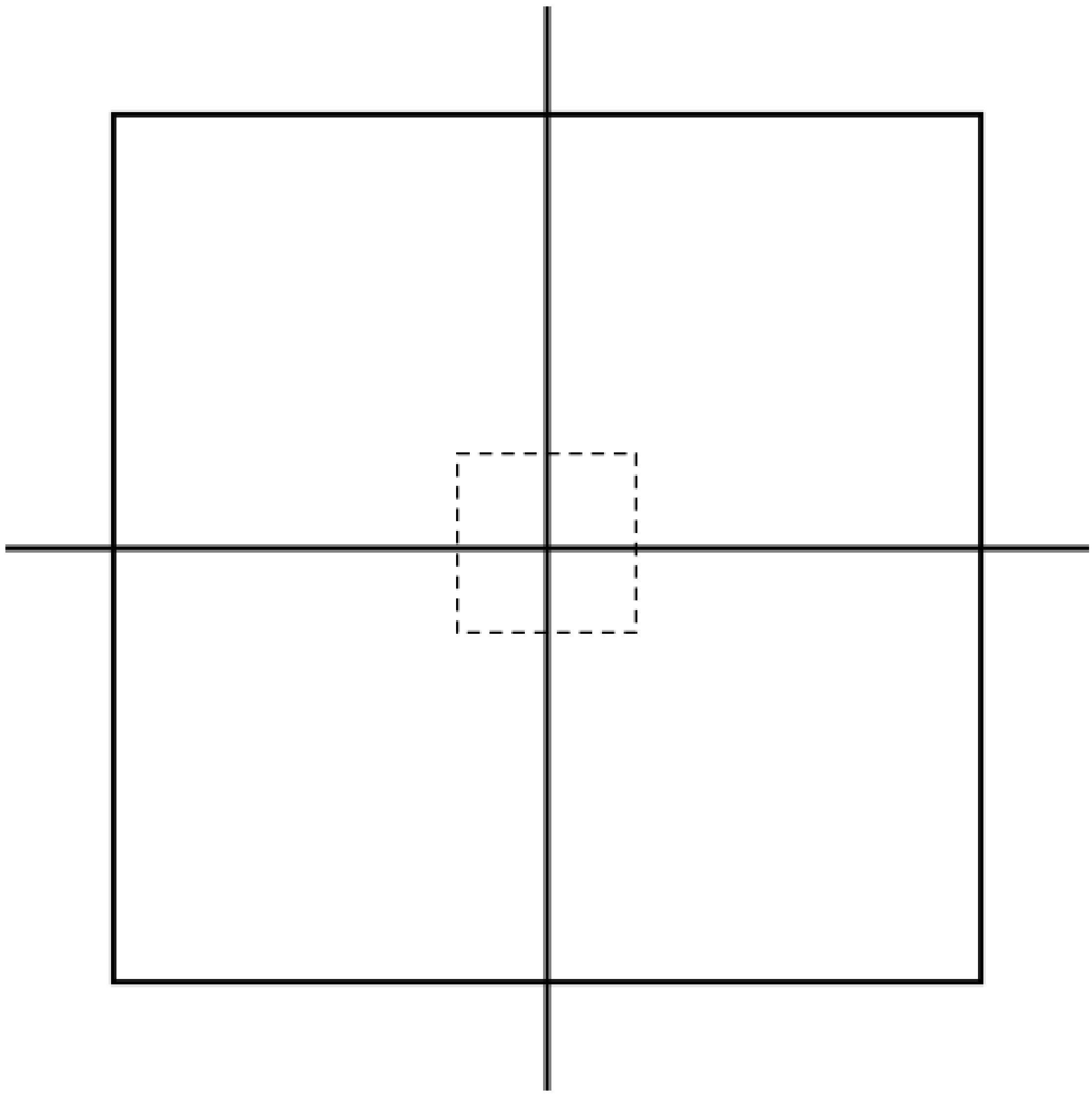
By calculating the percentage difference, **compare** the value of I_0 derived from the gradient of the graph and the value of half the illuminance measured with no polaroids in place.

Determine the y-intercept of the best fit straight line.

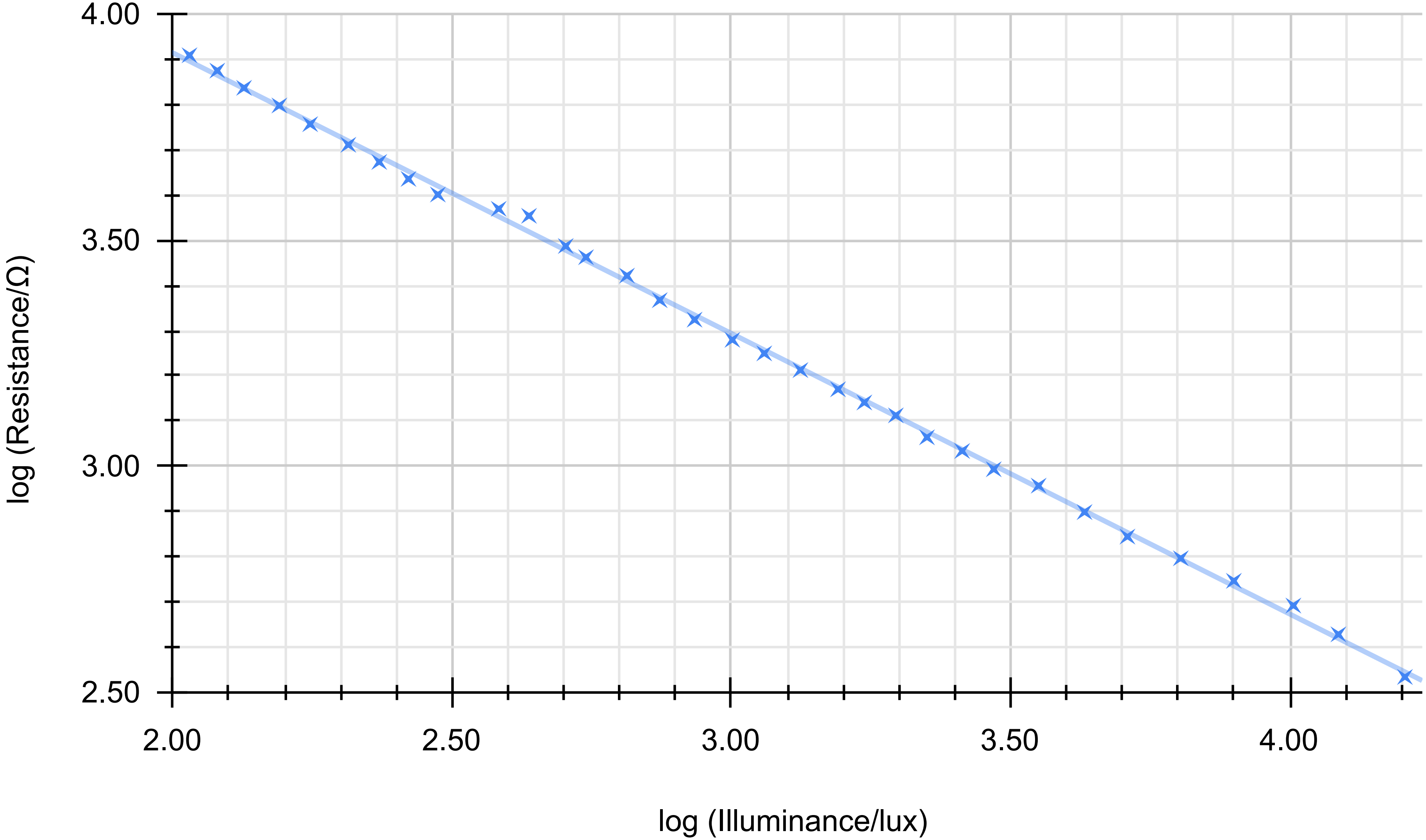
State the expected value for the y-intercept.

By considering the calculated values of the gradient and y-intercept, and their physical significance, **discuss** to what extent your results agree with Malus's law.


0
10
20
30
40
50
60
70
80
90



LDR Calibration Graph



$$\log(R/\Omega) = -0.62\ \log(I/\text{lux}) + 5.15$$

Note: Logarithms are Log base 10