

Name of the Student: _____

Max. Marks : 21 Marks

Time : 21 Minutes

Q1.

One of the two postulates of Einstein's theory of special relativity is that the speed of light in free space is invariant.

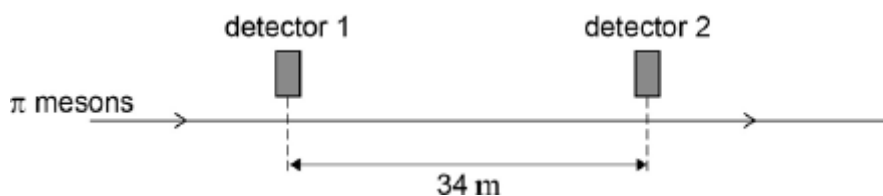
(a) Explain what is meant by this postulate.

(1)

(b) State the other postulate.

(1)

(c) Two detectors are measured to be 34 m apart by an observer in a stationary frame of reference. A beam of π mesons travel in a straight line at a speed of $0.95 c$ past the two detectors, as shown in the figure below.



Calculate the time taken, in the frame of reference of the observer, for a π meson to travel between the two detectors.

time = _____

- (d) π mesons are unstable and decay with a half-life of 18 ns.
It is found in experiments that approximately 75% of the π mesons that pass the first detector decay before reaching the second detector.

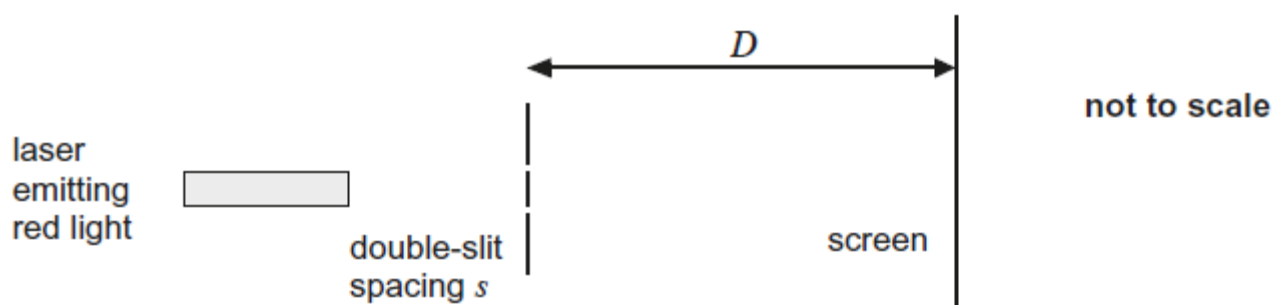
Show how this provides evidence to support the theory of special relativity. In your answer compare the percentage expected by the laboratory observer with and without application of the theory of special relativity.

(5)

(Total 8 marks)

Q2.

The diagram shows the arrangement of apparatus in an experiment to measure the wavelength of red light emitted by a laser. The light is incident on a double-slit so that an interference pattern is produced on the screen.



A student sets up the apparatus and measures the fringe width w of the interference pattern and the distance D between the double-slit and screen.

The student makes further measurements of w using the same laser but with different values of D and different slit spacing s .

The student's results are shown in the table below

D/m	$s/10^{-3} \text{ m}$	$\left(\frac{D}{s}\right)/10^3$	$w/10^{-3} \text{ m}$
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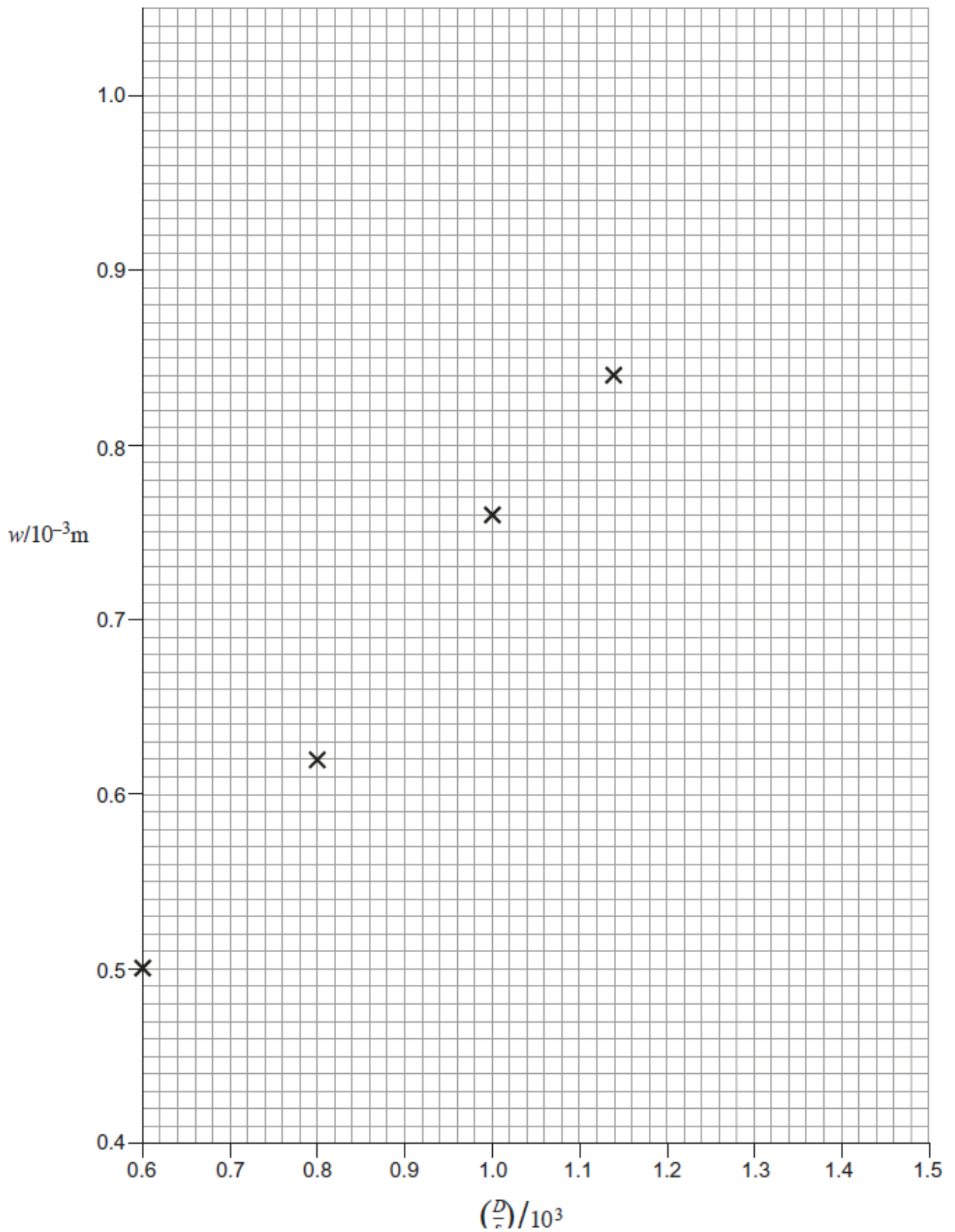
1.000	0.70		1.03
0.900	0.70		0.93
0.800	0.70	1.14	0.84
1.000	1.00	1.00	0.76
0.800	1.00	0.80	0.62
0.600	1.00	0.60	0.50

(a) Complete the table above.

(1)

(b) Complete the graph below by plotting the two remaining points and drawing a best fit straight line.

(2)



(c) (i) Determine the gradient of the graph above.

(3)

(ii) Determine the wavelength of the red laser light used in this experiment.

(1)

(d) (i) Theory suggests that the graph above should go through the origin.

State and explain what this suggests about the relationship between w and $\frac{D}{S}$.

(2)

(ii) The student discovers that the best fit line drawn in the graph does not go through the origin.

Determine, using information from the graph above, the value of w corresponding to

$$\left(\frac{D}{S}\right) = 0$$

(2)

(iii) The graph suggests a systematic error in a measurement.

Identify the measurement.

(1)

(e) The interference pattern produced on the screen is much brighter in the centre of the screen than at the edges.

State what causes this effect.

(1)
(Total 13 marks)