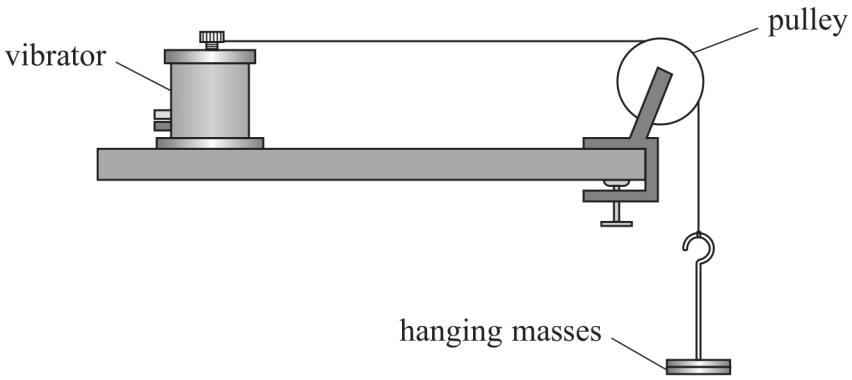
15 A student investigated stationary waves on a string, using the apparatus shown.



The frequency f of the vibrator was adjusted until a stationary wave was formed with a node at each end. This was repeated for various stationary waves on the string.
A metre rule was used to measure the distance d between adjacent nodes on the string.

(a) The resolution of the metre rule was 1 mm, but the measurements were recorded to the nearest 0.5 cm.

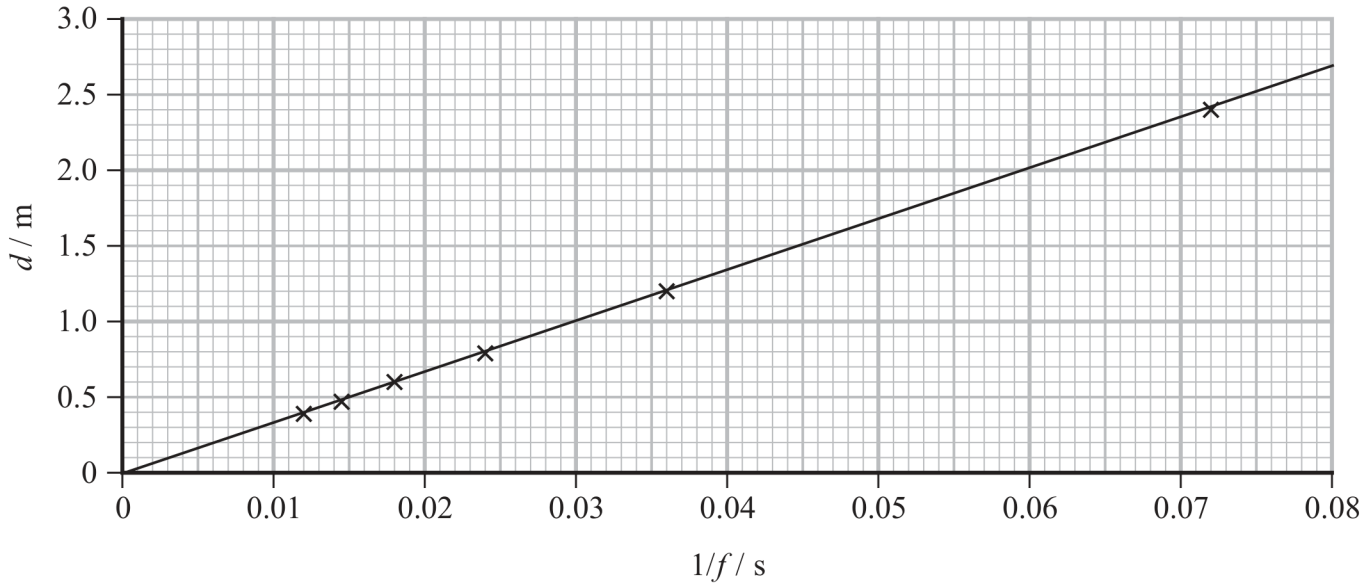
Suggest why.

(1)

.....

.....

(b) The student plotted a graph of d against $1/f$ as shown.



(i) Determine the total mass of the hanging masses used in the investigation.

mass per unit length of string = $4.5 \times 10^{-4}\,\text{kg m}^{-1}$

(5)

Total mass of hanging masses = ...

(ii) The string was replaced with one that had twice the mass per unit length.
The length of the string and the mass of the hanging masses did not change.

Add a line to the graph to show how d varied with $1/f$ for the new string.

(2)

(Total for Question 15 = 8 marks)