

State Examination Commission – Physics Higher Level, 2007

Question 1

A student investigated the laws of equilibrium for a set of co-planar forces acting on a metre stick. The student found that the centre of gravity of the metre stick was at the 50.4 cm mark and its weight was 1.2 N. How did the student find (i) the centre of gravity, (ii) the weight, of the metre stick? Why is the centre of gravity of the metre stick not at the 50.0 cm mark? The student applied vertical forces to the metre stick and adjusted them until the metre stick was in equilibrium. How did the student know that the metre stick was in equilibrium? (19)

The student recorded the following data

position on metre stick/cm	11.5	26.2	38.3	70.4	80.2
magnitude of force/N	2.0	4.5	3.0	5.7	4.0
direction of force	down	up	down	up	down

Calculate:

- (i) the net force acting on the metre stick
- (ii) the total clockwise moment about a vertical axis of the metre stick
- (iii) the total anti-clockwise moment about a vertical axis of the metre stick.

Use these results to verify the laws of equilibrium. (21)

How did the student find (i) the centre of gravity, (ii) the weight, of the metre stick?

The centre of gravity was found by pivoting the metre stick, until it was balanced, held in thread. The weight was found by finding its mass (in kg) on a top pan balance and multiplying by 9.8.

Why is the centre of gravity of the metre stick not at the 50.0 cm mark?

It may have been chipped or manufactured from material of non-uniform density.

How did the student know that the metre stick was in equilibrium?

The metre stick had a resultant force of zero and a resultant moment of zero (It was at rest)

Calculate:

- (i) the net force acting on the metre stick

$$\begin{array}{rclclclclclclclclclclcl} \text{Upward force} & = & 4.5 & + & 5.7 & & & = & 10.2 \text{ N} \\ \text{Downward force} & = & 2.0 & + & 3.0 & + & 4.0 & + & 1.2 & = & 10.2 \text{ N} \\ & & & & & & & & \text{Net force} & = & 0 \text{ N} \end{array}$$

- (ii) the total clockwise moment about a vertical axis (choose any) of the metre stick

$$\text{T.C.M. (through 0 mark)} = 2(0.115) + 3(0.383) + 1.2(0.504) + 4.0(0.802) = 5.2 \text{ N m}$$

- (iii) the total anti-clockwise moment about a vertical axis of the metre stick.

$$\text{T.A.C.M. (through same mark)} = 4.5(0.262) + 5.7(0.704) = 5.2 \text{ N m}$$

Use these results to verify the laws of equilibrium.

These results show that the sum of all the forces, and the sum of all the moments of those forces equal zero. These are the laws of equilibrium.