Past-paper walk-through

Rotational Equilibrium and Newton's First Law in Rotational Form ▪ 5.5

eXercise

Questions in this set

- 2025 Q3
- 2024 Q3

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 3

2025 ▪ Q3

Students are investigating balancing systems using the following setup. The students have a spring scale of negligible mass that is fixed to one end of a uniform meterstick. The center of the meterstick is attached to a stand on which the meterstick can pivot. There is a hook of negligible mass fixed to the top of a block of mass m_0. The hook can be attached to the meterstick through one of the small holes in the meterstick, as shown in Figure 1. The students do not have a direct way to measure the mass of the block. The block cannot be attached to the spring scale.

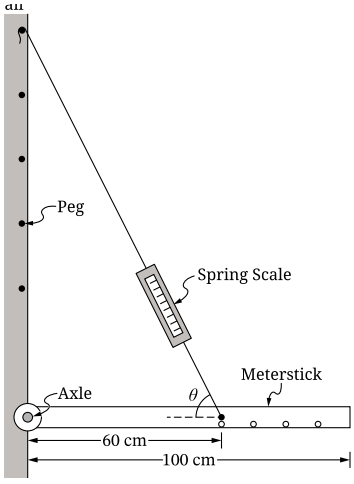
Figure 1

[Figure 1: A meterstick marked with cm labels 10, 20, 30, 40, (center pivot near 50), 60, 70, 80, 90 cm, with small holes shown at 60, 70, 80, 90 cm. A spring scale is attached to the left end of the meterstick (near 0 cm), held by a hand. The meterstick

Question 3

center is mounted on a stand allowing it to pivot. A block of mass m_0 hangs from a hook labeled "Block" that attaches via a small hole near the 80 cm mark.]
The students are asked to take measurements that will allow the students to create a linear graph whose slope could be used to determine the mass m_0 of the block.
(a) Describe an experimental procedure to collect data that would allow the students to determine m_0. Include any steps necessary to reduce experimental uncertainty.

Question 3



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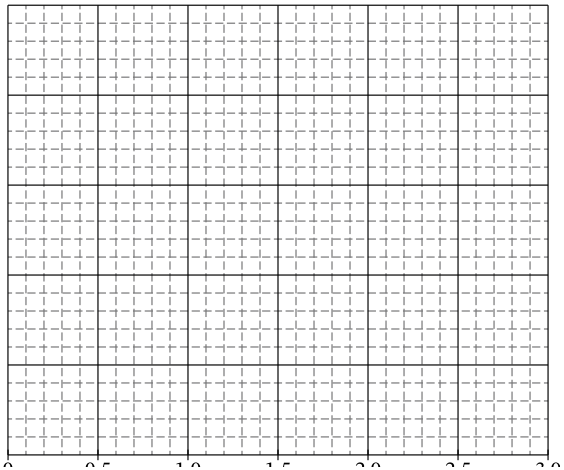

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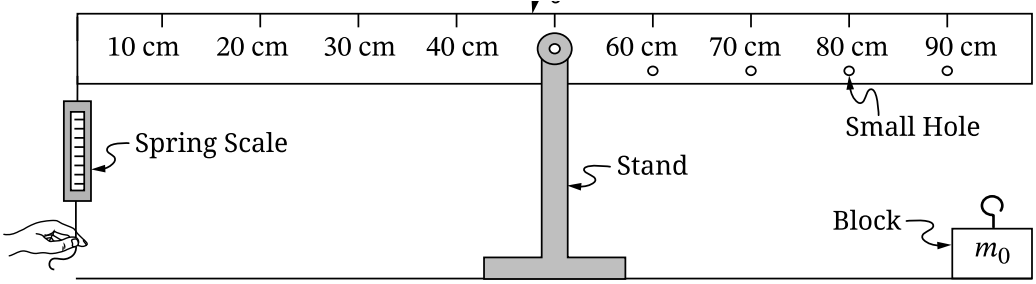
10 cm
20 cm
30 cm
40 cm
60 cm
70 cm
80 cm
90 cm
Spring Scale
Stand
Small Hole
Block
m_0

Question 3

2025 ▪ Q3

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The students are asked to take measurements that will allow the students to create a linear graph whose slope could be used to determine the mass m_0 of the block.

(b) **Describe** how the data collected in part A could be graphed and how that graph would be analyzed to determine m_0.

The students have an identical meterstick of mass M that is now attached to an axle that is fixed to a wall. The meterstick is free to rotate with negligible friction about the axle. The meterstick is suspended horizontally by a string that is connected to a spring scale of negligible mass, as shown in Figure 2.

Figure 2

[Figure 2: A meterstick attached horizontally to a wall via an axle at its left end. A string runs from a peg on the wall (one of several pegs shown vertically spaced on the wall) down at an angle θ to a spring scale, which connects to the meterstick at a point 60 cm from the axle. The meterstick extends to 100 cm total length. The horizontal

Question 3

distance from the axle to the string's attachment point on the meterstick is marked "60 cm", and the full meterstick length "100 cm" is marked from the axle to its far end.] The angle θ that the string makes with the meterstick can be varied by attaching the string to one of the pegs located along the wall. The students use the spring scale to measure the tension F_T required to hold the meterstick horizontal. Table 1 shows the measured values of θ and F_T.

Table 1

| θ (degrees) | F_T (N) | |—|—| | 22 | 21 | | 31 | 17 | | 36 | 13 | | 45 | 12 | | 80 | 8 |

The students correctly determine that the relationship between F_T and θ is given by

$$F_T = \frac{5Mg}{6\sin\theta}.$$

The students create a graph with $\dfrac{1}{\sin\theta}$ plotted on the horizontal axis.