1. A particle is in equilibrium under the action of three forces in newtons given by

$$\mathbf{F}_1 = \begin{pmatrix} 8 \\ 0 \end{pmatrix},\ \mathbf{F}_2 = \begin{pmatrix} 2a \\ -3a \end{pmatrix} \text{ and } \mathbf{F}_3 = \begin{pmatrix} 0 \\ b \end{pmatrix}.$$

Find the values of the constants a and b. [3]

2. Fig. 1 shows a pile of four uniform blocks in equilibrium on a horizontal table. Their masses, as shown, are 4 kg, 5 kg, 7 kg and 10 kg.

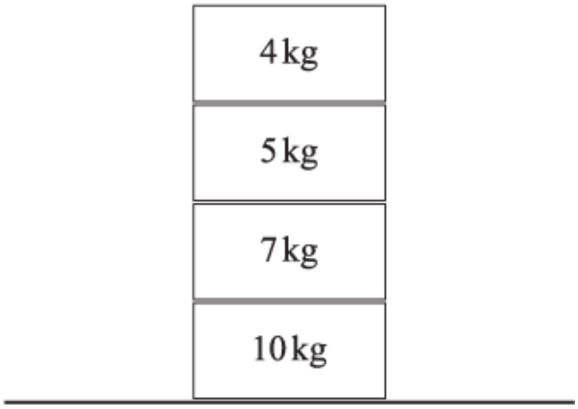


Fig.1

Mark on the diagram the magnitude and direction of each of the forces acting on the 7 kg block.

[3]

3. Fig. 3 shows a particle of weight 8 N on a rough horizontal table. The particle is being pulled by a horizontal force of 10 N. It remains at rest in equilibrium.

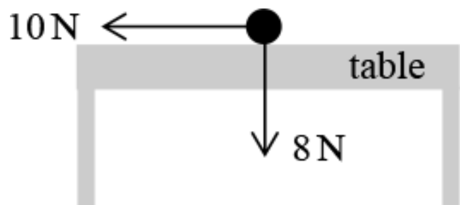


Fig. 3

(a) What information given in the question tells you that the forces shown in Fig. 3 cannot be the only forces acting on the particle? [1]

(b) The only other forces acting on the particle are due to the particle being on the table. State the types of these forces and their magnitudes. [2]

4. A block of mass $5m$ kg is in equilibrium on a rough horizontal table. It is connected by horizontal light inextensible strings over smooth pulleys to particles of mass m kg and $2m$ kg which hang freely, as shown in
Fig. 3.

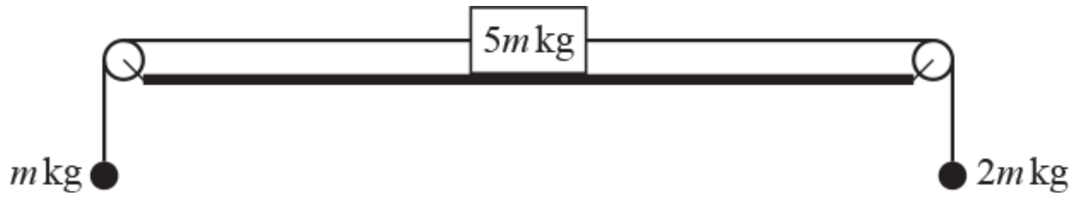
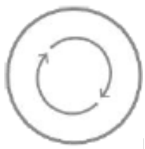
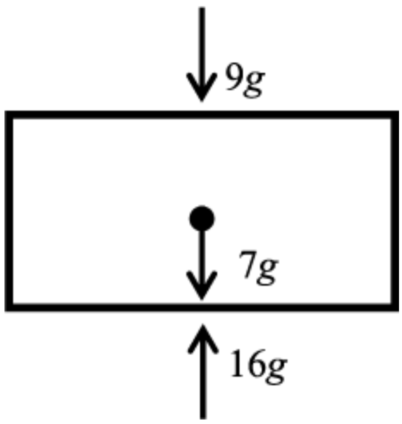


Fig. 3

Find the frictional force acting on the block, clearly indicating its direction. [3]

END OF QUESTION paper

Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			$\begin{pmatrix} 8 \\ 0 \end{pmatrix} + \begin{pmatrix} 2a \\ -3a \end{pmatrix} + \begin{pmatrix} 0 \\ b \end{pmatrix} = 0$ $a = -4$, b = −12	M1 (AO2.5) A1 (AO1.1b) A1 (AO1.1b) [3]	Setting up a correct vector equilibrium equation or two separate equations. Examiner's Comments Many candidates did not form an equilibrium equation in vector form nor a pair of equilibrium equations for the two directions. Many made the mistake of writing $F_1 + F_2 = F_3$ or similar and received no marks. Others had correct equations to obtain the method mark but subsequent sign errors cost the accuracy marks. n future teaching, emphasise to candidates the importance of setting up their equilibrium equation i.e. total force = 0
			Total	3	
2					One mark for each force with correct magnitude and direction
					Deduct 1 mark only for *g* missing
				B1	16g ↑
				B1	7g ↓
				B1	9g ↓

					If all three forces are correct but there is at least one extra force, deduct 1 mark and so give 2 marks. Otherwise ignore extra forces. Note For 16g ↑ 16g ↓ Award B1 B0 B0 Examiner's Comments This question, about drawing a force diagram, was not well answered. Candidates were expected to identify the three forces acting on a block and to mark each of them on a given diagram. Many tried to combine two of them, even though they were quite different forces; other answers can only be described as chaotic.
			Total	3	
3		a	E.g. The particle is in equilibrium [and the given forces cannot sum to zero as at 90°]	B1(AO2.2a) [1]	oe | Accept "without another force present, the particle would be moving on a rough surface without a frictional force"
		b	Friction 10 N [to give horizontal resultant of 0] Normal reaction from table. 8 N [to give vertical resultant of 0] **Alternative method** One extra force that gives equilibrium. Components 10 N → and 8 N ↑ Components from Friction → and normal reaction ↑	B1(AO3.3) B1(AO1.2) B1(AO3.3) B1(AO1.2) [2]	oe Accept 'Because the surface is rough' for 'Friction' Oe oe Accept $\sqrt{164}$ at ≈ 39° to horizontal oe Accept 'because the surface is rough' for 'Friction'
			Total	3	

4			Let T_1 and T_2 be the tensions in the strings to m kg mass and $2m$ kg mass respectively $T_1 = mg$ and $T_2 = 2mg$ $$T_2 - T_1 - F = 0$$ $F = mg$ towards the m kg mass (to the left on the diagram)	B1(AO 3.3) M1(AO 3.3) A1(AO 2.2a) [3]	For values of tensions clearly stated or shown on the diagram
			Total	3	

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