

QQQ – Mechanics Year 2 – Chapter 5 – Resolving Forces & Friction (Version 1)

Total Marks: 22

(22 = Platinum, 20 = Gold, 18 = Silver, 15 = Bronze)

1.



Figure 1

A particle P has mass 5 kg .

The particle is pulled along a rough horizontal plane by a horizontal force of magnitude 28 N .

The only resistance to motion is a frictional force of magnitude F newtons, as shown in Figure 1.

(a) Find the magnitude of the normal reaction of the plane on P (1)

The particle is accelerating along the plane at 1.4 m s^{-2}

(b) Find the value of F (2)

The coefficient of friction between P and the plane is μ

(c) Find the value of μ , giving your answer to 2 significant figures. (1)

(Total 4 marks)

Edexcel June 2023 Paper 3 Mechanics Q2

2. A 15 kg box is suspended in the air by a rope which makes an angle of 30° with the vertical.

The box is held in place by a string which is horizontal.

(a) Draw a diagram showing the forces acting on the box. [1]

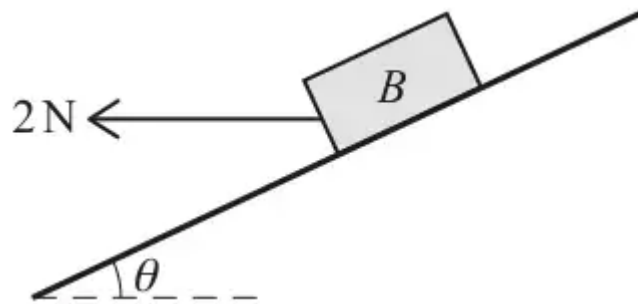
(b) Calculate the tension in the rope. [2]

(c) Calculate the tension in the string. [2]

(Total 5 marks)

OCR MEI June 2019 Paper 1 Q13

3.



A block B of weight 10 N lies at rest in equilibrium on a rough plane inclined at θ to the horizontal. A horizontal force of magnitude 2 N , acting above a line of greatest slope, is applied to B (see diagram).

(a) Complete the diagram in the Printed Answer Booklet to show all the forces acting on B .

[1]

It is given that B remains at rest and the coefficient of friction between B and the plane is 0.8 .

(b) Determine the greatest possible value of $\tan \theta$.

[5]

(Total 6 marks)

4. Fig. 11 shows two blocks at rest, connected by a light inextensible string which passes over a smooth pulley. Block A of mass 4.7 kg rests on a smooth plane inclined at 60° to the horizontal. Block B of mass 4 kg rests on a rough plane inclined at 25° to the horizontal. On either side of the pulley, the string is parallel to a line of greatest slope of the plane. Block B is on the point of sliding up the plane.

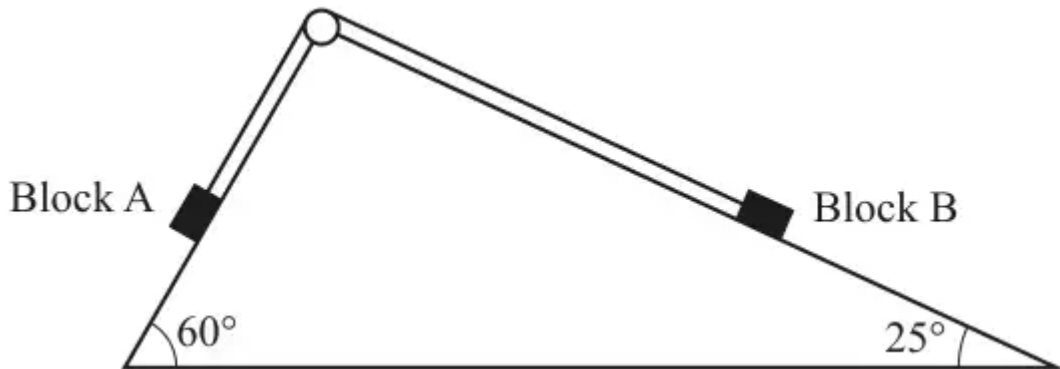


Fig. 11

- (i) Show that the tension in the string is 39.9 N correct to 3 significant figures. [2]
- (ii) Find the coefficient of friction between the rough plane and Block B. [5]

(Total 7 marks)

Solutions

1.

Mark scheme (a)

Scheme	Marks	AO
Resolve vertically, $R = 5g = 49$ (N)	B1	1.1b
	(1)	

Notes

B1: Allow either $5g$ or 49 . No penalty for using $g = 9.81$ or 10 .

Ignore any working. Must be a positive number.

BO if m is involved.

N.B. Could be seen on a diagram, provided it's clearly the reaction.

Mark scheme (b)

Scheme	Marks	AO
Equation of motion: $28 - F = 5 \times 1.4$	M1	3.1a
$F = 21$	A1	1.1b
	(2)	

Notes

M1: Equation with correct terms, dimensionally correct, condone sign errors.

A1: cao but allow $\frac{15g}{7}$. Ignore units.

Mark scheme (c)

Scheme	Marks	AO
$\mu = 0.43$ (2sf required)	B1 ft	3.4
	(1)	
	(4 marks)	

Notes

B1ft: $\mu = \frac{\text{their (b)}}{\text{their (a)}}$. **Answer must be a positive number given to 2sf.**

N.B.

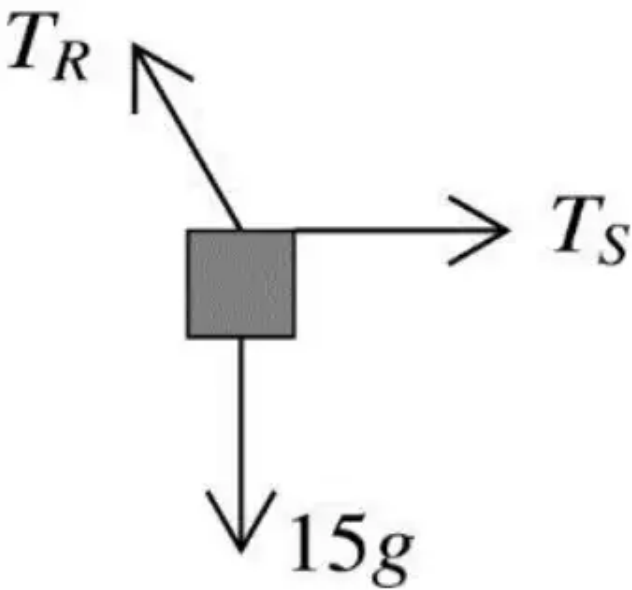
B0 if they use $g = 9.81$ or 10 in this part of the question.

Do not allow restarts.

Allow $\mu > 1$.

2.

Mark scheme (a)

Scheme	Marks	AO
	B1	1.1a
	[1]	

Notes

B1: Three forces in approximately correct directions, with arrows and labels; tensions must be distinct
Accept W or mg for the weight; condone missing g for this mark

Mark scheme (b)

Scheme	Marks	AO
Resolve vertically: $T_R \cos 30^\circ = 15g$	M1	3.3
$T_R = \frac{15 \times 9.8}{\cos 30^\circ} = 98\sqrt{3} = 170 \text{ N (3sf)}$	A1	1.1b
	[2]	

Notes

M1: Forming equilibrium equation (allow sin/cos interchange)

A1: Oe

Mark scheme (c)

Scheme	Marks	AO
Resolve horizontally: $T_S = T_R \sin 30^\circ$	M1	1.1a
$T_S = 84.9 \text{ N}$ (3sf)	A1	1.1b
	[2]	

Notes

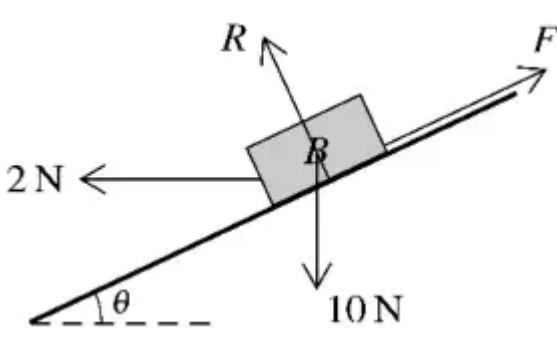
M1: Allow sin/cos interchange if consistent with (b)

Accept $T_S = 15g \tan 30^\circ$

A1: Oe

3.

Mark scheme (a)

Scheme	Marks	AO
	B1	1.2
	[1]	

Notes

B1: Correct force diagram showing the weight, normal contact, and frictional contact forces only (but ignore labelling of these forces even if labelled incorrectly) but must include all arrows pointing in the correct direction – the line of action of all forces must pass through the block (or imply passing through the block) but do not need to be attached to the block

Ignore components of any of the three forces if shown – if **only** components shown then **B0**

Mark scheme (b)

Scheme	Marks	A0
	M1*	3.3
$R + 2 \sin \theta = 10 \cos \theta$	A1	1.1
$F = 2 \cos \theta + 10 \sin \theta$	A1	1.1
$2 \cos \theta + 10 \sin \theta \leq 0.8(10 \cos \theta - 2 \sin \theta)$	M1dep*	3.4
$10 \cos \theta + 50 \sin \theta \leq 40 \cos \theta - 8 \sin \theta$ ($\tan \theta \leq \frac{30}{58} \Rightarrow$ greatest value of) $\tan \theta$ is $\frac{15}{29}$	A1	2.2a
	[5]	

Notes

M1*: Resolving parallel **or** perpendicular to the plane – correct number of terms - **must** be using 10 for the weight so no marks until this value used/applied (however, see **SC** in the final **A** mark)

Allow sin/cos confusion and sign errors – **but the 2 and 10 must be resolved and the R and F should not** (if considering $\perp$ & $\parallel$)

A1 A1: Condone $\leq$ or $\geq$ with F for this mark but withhold the final **A** mark

Where R is the normal contact force and F is the frictional contact force

M1dep*: Applying $F \leq \mu R$ or $F = \mu R$ to obtain an equation/inequality in θ only – where R and F are a linear combination of the correct number of relevant resolved terms

A1: oe e.g. $\frac{30}{58}$ but **A0** for $\frac{6}{11.6}$ as a final answer. Allow awrt 0.517. Isw if candidates go on to work out θ .

Allow $\tan \theta \leq \frac{15}{29}$ (oe) as a final answer

Can use equals throughout (no justification required) But **not** $\tan \theta < \frac{15}{29}$

If using 10g for the weight, then SC M1* A1 A0 M1dep* A0 max (where the first A mark is for both equations correct using 10g rather than 10)

Alternative for first three marks

Scheme	Marks
Resolving vertically and horizontally	M1*
$R \cos \theta + F \sin \theta = 10$	A1
$F \cos \theta = 2 + R \sin \theta$	A1

M1*: M1 conditions as above

A1: Final M1dep* and A marks as above

4.

Mark scheme (i)

Scheme	Marks	AO
Component of weight down the plane $4.7g \sin 60^\circ$	B1	2.1
Equilibrium equation $T = 4.7g \sin 60^\circ$ $= 39.889 \dots$ so $T = 39.9$ to 3 sf	E1	3.3
	[2]	

Notes

AG

B1: Award if seen

E1: Must be clear that 39.9 N is the tension and not just component of weight

Mark scheme (ii)

Scheme	Marks	AO
Resolve perpendicular to the slope N is the normal reaction between plane and block B $N = 4g \cos 25^\circ$	B1	1.1a
Resolve up the slope $T - F - 4g \sin 25^\circ = 0$	M1 A1	3.3 1.1b
On the point of sliding so $F = \mu N = \mu \times 4g \cos 25^\circ$	M1	3.1b
$\mu = \frac{4.7g \sin 60^\circ - 4g \sin 25^\circ}{4g \cos 25^\circ} = 0.656$ to 3sf	A1	1.1b
	[5]	

Notes

B1: Need not be evaluated here [≈ 35.5]

M1: Allow only sign errors

A1: F need not be evaluated here [≈ 23.3]

M1: Do not allow for $F \leq \mu N$ unless = used subsequently. FT their values.

A1: FT (notice this answer is 0.657 if 39.9 used for T)

If only values are seen used, it must be clear that the values used are friction and normal reaction.