OCR
Oxford Cambridge and RSA

# A Level Mathematics B (MEI)

**H640/01** MEI Pure Mathematics and Mechanics

Mechanics

## Question Set 2

1. Fig. 1 shows a uniform beam of mass 4 kg and length 2.4 m resting on two supports P and Q. P is at one end of the beam and Q is 0.3 m from the other end.
Determine whether a person of mass 50 kg can tip the beam by standing on it. [3]

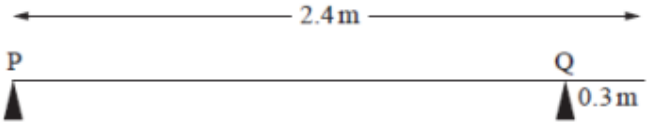
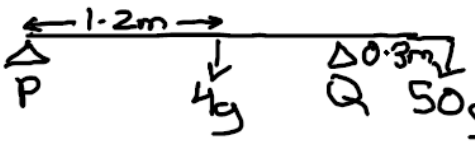



Fig. 1

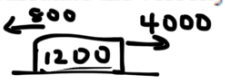



The maximum clockwise moment by the person
$= 50g \times 0.3 = 147N$

The anticlockwise moment of the weight $= 4g \times 0.9$
$= 35.28N$. As $147 > 35.28$, the beam will tip.

2. A car of mass 1200 kg travels from rest along a straight horizontal road. The driving force is 4000 N and the total of all resistances to motion is 800 N.

a) Calculate the velocity of the car after 9 seconds. [4]




$F = Ma$
$4000 - 800 = 1200a$
$\frac{8}{3} = a$

| | |
|---|---|
| S | |
| U | 0 |
| V | x |
| A | 8/3 |
| T | 9 |

$V = U + at$
$V = 8/3 \times 9$
$V = 24 ms^{-1}$

3. The velocity $v$ ms$^{-1}$ of a particle at time $t$ s is given by

$v = 0.5t(7 - t)$.

a) Determine whether the speed of the particle is increasing or decreasing when $t = 8$. [4]

$V = 0.5t(7-t)$
$V = \frac{7}{2}t - \frac{1}{2}t^2$

$\frac{dV}{dt} = \frac{7}{2} - t$ } acceleration
$= \frac{7}{2} - 8 = -\frac{9}{2}$

the acceleration is $-4.5$ ∴ the particle is slowing down

4. A cannonball is fired from a point on horizontal ground at $100\,\mathrm{m\,s^{-1}}$ at an angle of $25°$ above the horizontal. Ignoring air resistance, calculate

a) the greatest height the cannonball reaches, [3]


$x = 100\cos 25\, t$

$y = 100\sin 25 t - 4.9 t^2$

S x
U 100sin 25
V 0
A -9.8
T

$V^2 = U^2 + 2aS$

$0 = (100\sin 25)^2 + (2 \times -9.8)S$

$S \simeq 91.1\,m$

b) the range of the cannonball. [4]

S
U 100sin 25
V 0
A -9.8
T x

$V = U + at$

$0 = 100\sin 25 + -9.8t$

$4.321 = t$

$\therefore$ range $t = 4.312 \times 2$

$\hookrightarrow 8.624$

S x
U 100cos 25
V
A 0
T 8.624

$S = ut + \frac{1}{2}at^2$

$S = 100\cos 25 \times 8.624$

$S = 781.67\,m$

$S = 782\,m$

5. In this question, the unit vector **i** is horizontal and the unit vector **j** is vertically upwards.

A particle of mass 0.8 kg moves under the action of its weight and two forces given by $(k\mathbf{i}+5\mathbf{j})$ N and $(4\mathbf{i}+3\mathbf{j})$ N. The acceleration of the particle is vertically upwards.

a) Write down the value of $k$. [1]

$4i+ki=0$

$k=-4$

b) Initially the velocity of the particle is $(4\mathbf{i}+7\mathbf{j})\,\text{ms}^{-1}$.

Find the velocity of the particle 10 seconds later. [4]

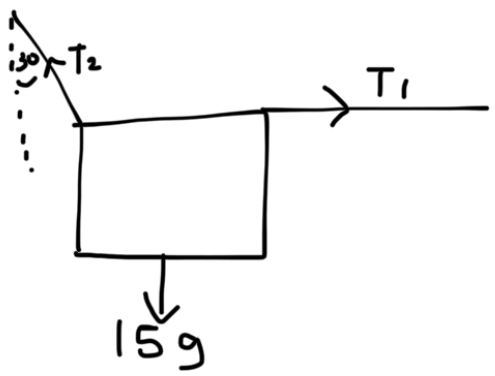
$F_{res}=4i+3j-4i+5j-0.8gj=0.16j$

$0.16j=0.8a$ so $a=0.2j$.

$v=u+at=\begin{pmatrix}4\\7\end{pmatrix}+\begin{pmatrix}0\\0.2\end{pmatrix}10=4i+9j$

6. 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]

$T_2 \cos 30 = 15g$

$T_2 = 167.7$

$T_2 = 170_N$

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

$169.7 \sin 30 = T_1$

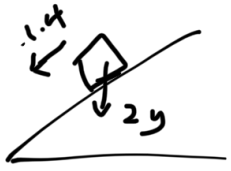
$84.9 = T_1$

$85_N = T_1$

7. A particle of mass 2 kg slides down a plane inclined at 20° to the horizontal. The particle has an initial velocity of $1.4\,ms^{-1}$ down the plane. Two models for the particle's motion are proposed.

In model A the plane is taken to be smooth.

a) Calculate the time that model A predicts for the particle to slide the first 0.7 m. [5]




$F = ma$

$2g \sin 20 = 2a$

$3.35 = a$

S 0.7 ←+

U 1.4

V

A 3.35

T x

$S = ut + \frac{1}{2}at^2$

$0.7 = 1.4t + \frac{3.35}{2}t^2$

$t = 0.352$

$t = 0.35$

b) Explain why model A is likely to underestimate the time taken. [1]

It does not take into account friction

In model B the plane is taken to be rough, with a constant coefficient of friction between the particle and the plane.

c) Calculate the acceleration of the particle predicted by model B given that it takes 0.8 s to slide the first 0.7 m. [2]

S 0.7
U 1.4
V
A x
T 0.8

$S = ut + \frac{1}{2}at^2$

$0.7 = (1.4 \times 0.8) + (\frac{1}{2} \times 0.8^2)a$

$-1.3125 = a$

$-1.31 = a$

d) Find the coefficient of friction predicted by model B, giving your answer correct to 3 significant figures. [6]

$2g\sin 20 - F = -1.31 \times 2$

$F = 9.328594$

$N = 2g\cos 20$

$F = \mu R$

$9.328594 = \mu\, 18.147975$

$0.506 = \mu$

**Total Marks for Question Set 2: 42**