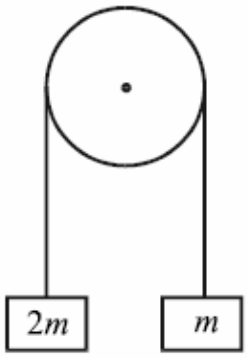
2004 – FORCES QUESTION

4. **(a)** Two particles, of masses $2m$ and m, are attached to the ends of a light inextensible string which passes over a fixed smooth light pulley.

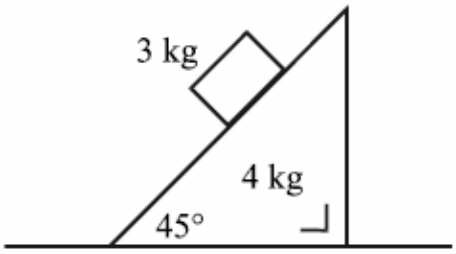


The system is released from rest with both particles at the same horizontal level.

(i) Find the acceleration of the system, in terms of g.

(ii) The string breaks when the speed of each particle is v.
Find, in terms of v, the vertical distance between the particles when the string breaks.

(b) A smooth wedge of mass 4 kg and slope 45° rests on a smooth horizontal surface.
A particle of mass 3 kg is placed on the smooth inclined face of the wedge.
The system is released from rest.



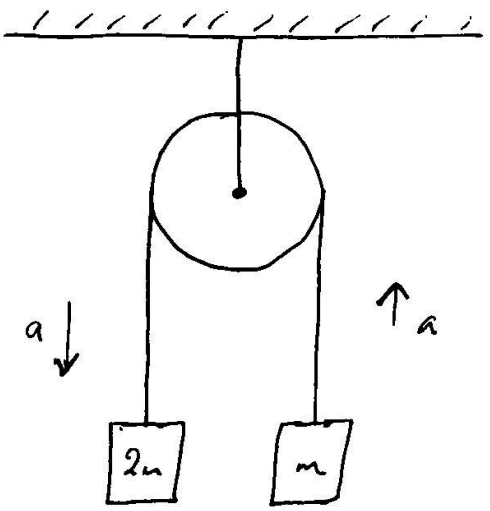
(i) Show, on separate diagrams, the forces acting on the wedge and on the particle.

(ii) Find the acceleration of the particle relative to the wedge.

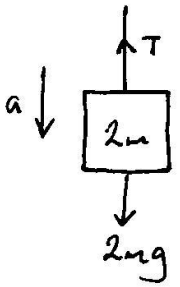
(iii) Find how far the wedge has travelled when the particle has moved a distance of 1 m down the inclined face of the wedge.

2004

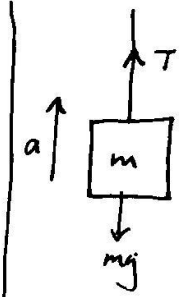
Q4/(a)



(i)



$2mg - T = 2ma$



$T - mg = ma$

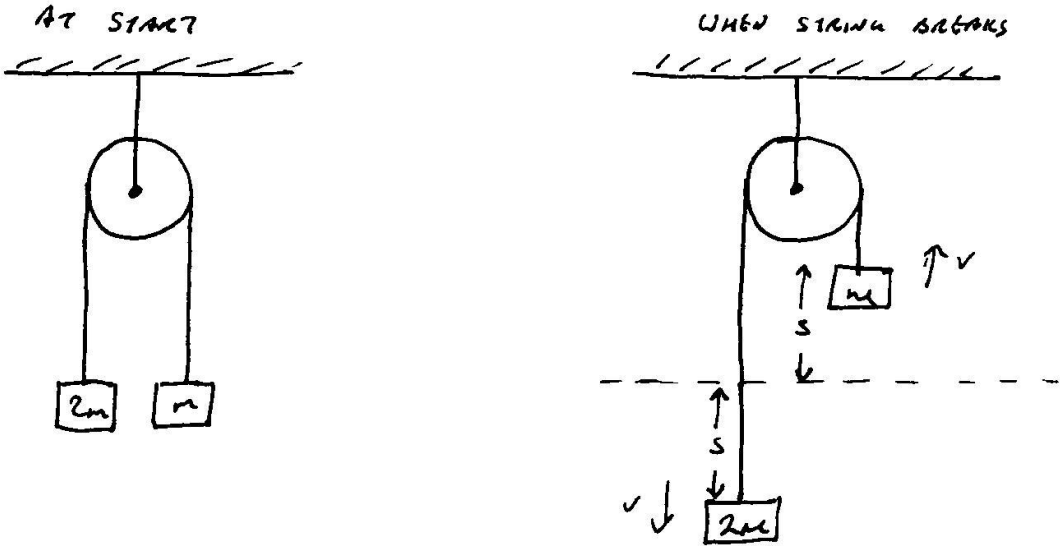
SIMULTANEOUS EQUATIONS:

$$2mg - T = 2ma$$
$$-mg + T = ma$$

$$mg = 3ma$$

$$\frac{g}{3} = a$$

(ii)



* FIND DISTANCE TRAVELLED BY $2m$ BLOCK IN REACHING SPEED V.

$u = 0$
$v = V$
$a = \frac{g}{3}$
$s = ?$
$t = -$

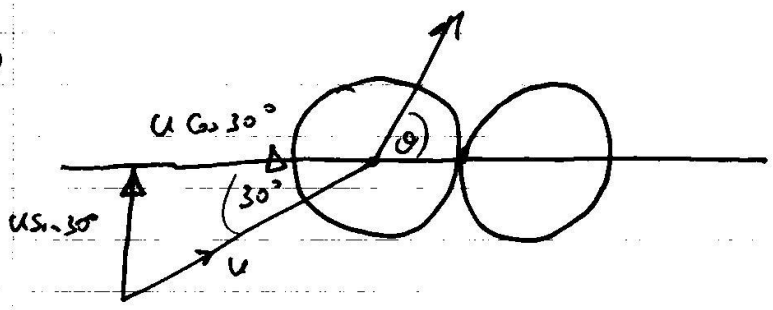
$$v^2 = u^2 + 2as$$
$$V^2 = (0)^2 + 2\left(\frac{g}{3}\right)s$$
$$V^2 = \frac{2g}{3}s$$
$$\frac{3V^2}{2g} = s$$

SINCE THE PARTICLES WERE ATTACHED BY THE SAME STRING, THE m BLOCK WILL HAVE MOVED UPWARD BY THE SAME DISTANCE.

SO THE VERTICAL DISTANCE BETWEEN THE BODIES IS:

$$\frac{3V^2}{2g} + \frac{3V^2}{2g} = \frac{6V^2}{2g} = \underline{\underline{\frac{3V^2}{g}}}$$

Q5 (b)



	BEFORE	MASS	AFTER
(1)	$u\cos 30^\circ \vec{i} + u\sin 30^\circ \vec{j}$	m	$p\vec{i} + u\sin 30^\circ \vec{j}$
	$\Rightarrow \frac{u\sqrt{3}}{2}\vec{i} + \frac{u}{2}\vec{j}$		$p\vec{i} + \frac{u}{2}\vec{j}$
(2)	$0\vec{i} + 0\vec{j}$	m	$q\vec{i} + 0\vec{j}$

Con. of Mom:

$$\left(\frac{u\sqrt{3}}{2}\right)(m) + (0)(m) = p(m) + q(m)$$

$$\frac{u\sqrt{3}}{2} = p + q \quad \ldots \boxed{u\sqrt{3} = 2p + 2q}$$

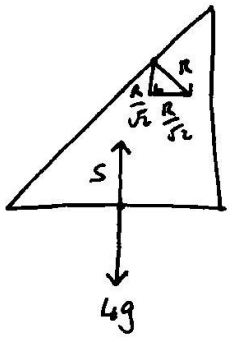
Coeff. of Res.:

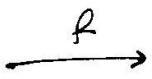
$$\frac{p - q}{\frac{u\sqrt{3}}{2} - 0} = -e$$

$$p - q = -\frac{eu\sqrt{3}}{2}$$

$$\boxed{2p - 2q = -eu\sqrt{3}}$$

Wedge:





• Discount ⊥ forces

II forces:

$\frac{R}{\sqrt{2}} = 4f$

$\boxed{R = 4\sqrt{2}f}$ ③

(ii) Solving: ① $3g - R\sqrt{2} = 3f$ ② $3g = 3\sqrt{2}a - 3f$

③ $R = 4\sqrt{2}f$

① $3g - (4\sqrt{2}f)(\sqrt{2}) = 3f$

$3g - 8f = 3f$

$3g = 11f$

$\boxed{\frac{3g}{11} = f}$

② $3g = 3\sqrt{2}a - 3f$

$3g = 3\sqrt{2}a - 3\left(\frac{3g}{11}\right)$

$3g = 3\sqrt{2}a - \frac{9g}{11}$

$\frac{42g}{11} = 3\sqrt{2}a$

$\boxed{\frac{14g}{11\sqrt{2}} = a}$

(iii) FIND TIME TAKEN FOR PARTICLE TO TRAVEL 1m:

$u = 0$
$v = -$
$a = \frac{14g}{11\sqrt{2}}$
$s = 1$
$t = ?$

$$s = ut + \tfrac{1}{2}at^2$$

$$1 = (0)(t) + \tfrac{1}{2}\left(\frac{14g}{11\sqrt{2}}\right)t^2$$

$$1 = \frac{7g}{11\sqrt{2}}t^2$$

$$\frac{11\sqrt{2}}{7g} = t^2$$

FIND DISTANCE BY WEDGE IN THIS TIME:

$u = 0$
$v = -$
$a = \frac{3g}{11}$
$s = ?$
$t^2 = \frac{11\sqrt{2}}{7g}$

$$s = ut + \tfrac{1}{2}at^2$$

$$s = 0(t) + \tfrac{1}{2}\left(\frac{3g}{11}\right)\left(\frac{11\sqrt{2}}{7g}\right)$$

$$s = \frac{3\sqrt{2}}{14}$$