

# Solutionbank M1

Heinemann Modular Maths for Edexcel AS and A-level

## 6 Connected particles

### Exercise A, Question 19

#### Question:

A particle, of mass  $M$ , is on a rough horizontal table. A light, inextensible string is attached to this particle and passes over a smooth pulley. Attached to the other end of the string, so that it hangs vertically, is another particle of mass  $m$ . The coefficient of friction between the particle and the table is  $\mu$ . The particles are initially at rest.

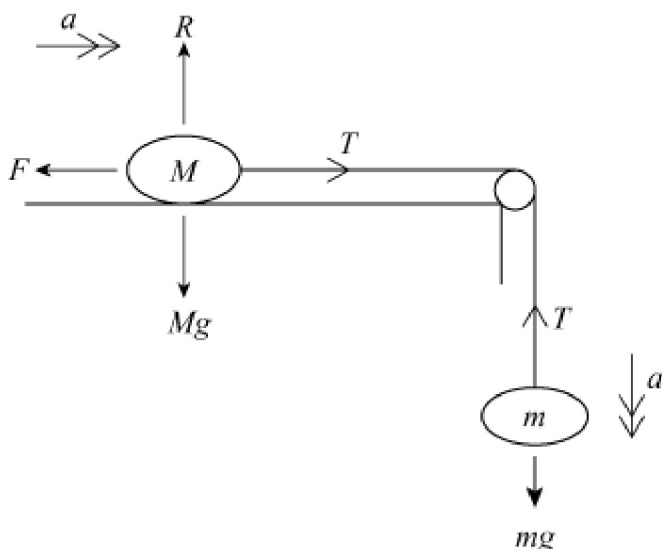
(a) Show that the acceleration of the particles is  $\frac{g(m - \mu M)}{m + M}$ .

(b) Find the tension in the string.

(c) Find the time that it takes the particle on the table to move 0.5 m and its speed at this time.

#### Solution:

(a)



Resolve vertically for particle  $M$ ;  $R$

$$= Mg$$

Using  $F = \mu R$  for this particle,  $F$

$$= \mu Mg$$

Using  $F = ma$  for particle  $M$  (horizontally);  $T - \mu Mg$

$$= Ma$$

for particle  $m$  (vertically);  $mg - T$

$$= ma \quad [1]$$

Adding  $mg - \mu Mg$

$$= ma + Ma$$

$\therefore a$

$$= \frac{g(m - \mu M)}{m + M}$$

$$\begin{aligned} \text{From [1] } T &= mg - ma \\ &= mg - m \frac{g(m - \mu M)}{m + M} \end{aligned}$$

$$\begin{aligned} \text{(b)} \quad &= \frac{Mmg + mM\mu g}{m + M} \\ &= \frac{mMg(1 + \mu)}{m + M} \end{aligned}$$

Using  $s = ut + \frac{1}{2}at^2$  to find the time taken to move 0.5 m,

$$0.5 = \frac{1}{2} \times \frac{g(m - \mu M)}{m + M} t^2$$

$$\text{(c)} \quad \therefore t = \sqrt{\frac{m + M}{g(m - \mu M)}}$$

To find the speed, using  $v^2 = u^2 + 2as$

$$v^2 = 2 \times \frac{g(m - \mu M)}{m + M} \times 0.5$$

$$v = \sqrt{\frac{g(m - \mu M)}{m + M}}$$