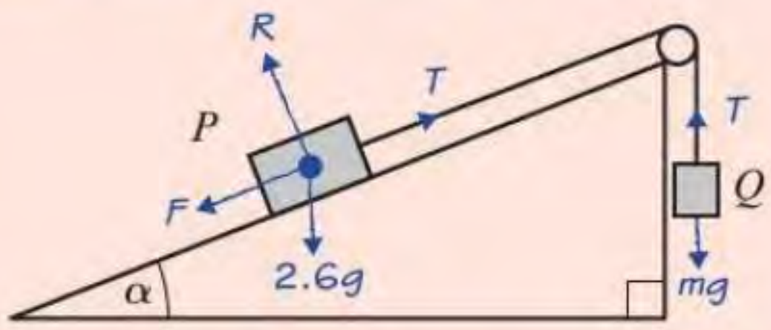
Had a look ☐ Nearly there ☐ Nailed it! ☐

Connected particles 2

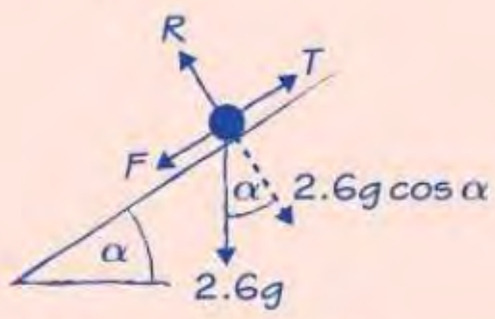
When two particles are connected via a pulley, one particle might be on a **plane**. If the plane is **rough**, you'll have to consider **friction** as well. Have a look at page 168 for a reminder.

Worked example



Two particles P and Q have masses 2.6 kg and m kg respectively. The particles are attached to the ends of a light inextensible string that passes over a smooth pulley which is fixed at the top of a rough plane. The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{5}{12}$
The coefficient of friction between P and the plane is 0.5. The particle P is held at rest on the inclined plane and the particle Q hangs freely below the pulley with the string taut. The system is released from rest and Q accelerates vertically downwards at $1.8\,\text{m s}^{-2}$. Find

(a) the magnitude of the normal reaction of the inclined plane on P **(2 marks)**



R(↖): $R - 2.6g\cos\alpha = 0$

Using $\cos\alpha = \frac{12}{13}$: $R = 2.6g \times \frac{12}{13}$

$= 24\,\text{N}$ (2 s.f.)

(b) the value of m. **(8 marks)**

R(↗): Using $F = ma$ for P to find T:

$T - F - 2.6g\sin\alpha = 2.6 \times 1.8$

Using $\sin\alpha = \frac{5}{13}$: $T - F = 14.48$ ①

$F = \mu R = 0.5 \times 24 = 12$

Substituting into ①: $T - 12 = 14.48$

$T = 26.48\,\text{N}$

R(↓): Using $F = ma$ on Q:

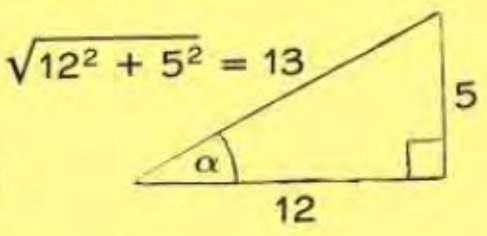
$mg - T = 1.8m$

$9.8m - 26.48 = 1.8m$

$8m = 26.48$

$m = 3.31 = 3.3\,\text{kg}$ (2 s.f.)

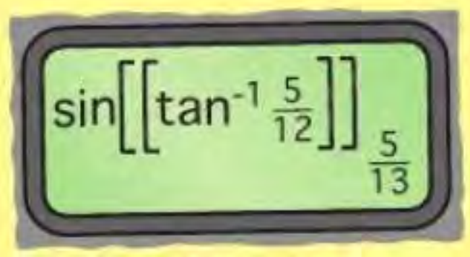
You have been given $\tan\alpha = \frac{5}{12}$. You can sketch a right-angled triangle to work out exact values of $\sin\alpha$ and $\cos\alpha$:



$\sin\alpha = \frac{5}{13}$

$\cos\alpha = \frac{12}{13}$

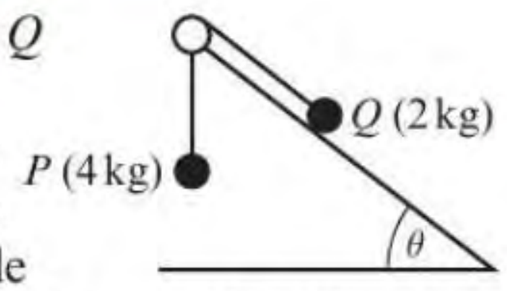
You might also be able to find these fractions on your calculator:



Resolve **parallel** to the plane to write an equation of motion for P, and resolve **vertically** to write an equation of motion for Q.

Now try this

Two particles P and Q of masses 4 kg and 2 kg respectively are attached to the ends of a light inextensible string, which runs over a smooth pulley. Q is held at rest on a rough plane inclined at an angle θ to the horizontal, where $\tan\theta = \frac{3}{4}$. The coefficient of friction between Q and the plane is $\frac{1}{4}$. The particles are released from rest and Q accelerates up the plane.



(a) Find the acceleration of Q. **(10 marks)**

After 0.6 s, particle P hits the floor and remains there. Particle Q continues up the slope, reaching its highest point after a further T s. In this motion Q does not reach the pulley.

(b) Find the value of T. **(6 marks)**

Answer

Answer

You need to use the ***suvat*** formulae for part (b). u will be the speed of Q after 0.6 s, and v will be 0.

Have a look at pages 150 and 151 for a reminder.