## Section 2: Moments of forces at an angle

## Section test

1. Find the anticlockwise moment of the 10 N force about the point A in the diagram below. Give your answer to 3 s.f.

2. Find the total anticlockwise moment of the forces shown about the point $A$ in the diagram below. Give your answer to 3 s.f.

3. In the diagram below, the total moment of the forces shown about O is zero. The length of the rod (which has negligible weight) is 6 m . How far from O does the 12 N force act?

4. A ladder of mass 8 kg and length 4 m is placed against a smooth wall, with its foot on rough horizontal ground, making an angle of $60^{\circ}$ with the ground.. A woman of mass 60 kg stands 1 m from the top of the ladder. Find the frictional force between the foot of the ladder and the ground.
5. A uniform beam AB of mass 10 kg is freely hinged at A and is kept horizontal by a string from B to a point vertically above A. The string makes an angle of $30^{\circ}$ with the beam. Find, in terms of $g$, the tension in the string.
Find, in terms of $g$, the magnitude of the reaction at the hinge.
Find the angle which the reaction with the hinge makes with AB.
6. A heavy rod AB of mass 25 kg and length 2.4 m is hinged at A to a point on a vertical wall. It is kept horizontal by a chain attached to $B$ and to a point 1.5 m vertically above $A$. The bar carries an additional mass of $10 \mathrm{~kg}, 1.8 \mathrm{~m}$ from A.

Find the tension in the chain.
Find the magnitude of the reaction at A .
Find the direction of the reaction at A .

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## Solutions to section test

1) Moment $=8 \times 10 \sin 25^{\circ}=33.8 \mathrm{Nm}$
2) Total moment anticlockwise $=5 \times 4 \sin 35^{\circ}-5 \times 3=-3.53$
3) Let the distance of the 12 N force from 0 be $\times \mathrm{m}$.
$6 \times 8 \sin 30^{\circ}-12 x=0$
$x=2$
so the force is 2 m from 0 .
4) 



Resolving vertically: $\quad R-8 g-60 g=0$

$$
R=689
$$

Taking moments about $A$ :

$$
\begin{aligned}
& 60 g \cos 60^{\circ} \times 1+8 g \cos 60^{\circ} \times 2+F \sin 60^{\circ} \times 4-R \cos 60^{\circ} \times 4=0 \\
& 30 g+8 g+2 F \sqrt{3}-2 R=0 \\
& 38 g+2 F \sqrt{3}-136 g=0 \\
& 2 F \sqrt{3}=98 g \\
& F=\frac{98 \times 9.8}{2 \sqrt{3}}=277 \mathrm{~N}(3 \mathrm{s.f.})
\end{aligned}
$$

5) 



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Taking moments about A:

$$
\begin{aligned}
& T \sin 30^{\circ} \times 2 \not /-10 g \times \neq 0 \\
& T \times \frac{1}{2} \times 2=10 g \\
& T=10 g
\end{aligned}
$$

Taking moments about $B$ :

$$
\begin{aligned}
& Y \times 2 \not-10 g \times \neq=0 \\
& 2 Y=10 g \\
& Y=5 g \\
& X-T \cos 30^{\circ}=0
\end{aligned}
$$

Resolving horizontally:
$x=\log \times \frac{\sqrt{3}}{2}=59 \sqrt{3}$
Magnitude of reaction $=\sqrt{x^{2}+y^{2}}$

$$
\begin{aligned}
& =\sqrt{75 g^{2}+25 g^{2}} \\
& =10 g
\end{aligned}
$$


$\tan \theta=\frac{59}{5 g \sqrt{3}}=\frac{1}{\sqrt{3}}$
$\theta=30^{\circ}$
6)

$\tan \theta=\frac{1.5}{2.4}$
$\theta=32^{\circ}$
Taking moments about A:

$$
\begin{aligned}
& 25 g \times 1.2+10 g \times 1.8-T \sin \theta \times 2.4=0 \\
& 48 g=2.4 T \sin 32^{\circ} \\
& T=370 \text { (3 s.f.) }
\end{aligned}
$$

Taking moments about B:

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$$
\begin{aligned}
& 2.4 Y-25 \mathrm{~g} \times 1.2+10 \mathrm{~g} \times 0.6=0 \\
& 2.4 Y=36 \mathrm{~g} \\
& Y=15 \mathrm{~g}=147
\end{aligned}
$$

Resolving horizontally:

$$
\begin{aligned}
& X-T \cos \theta=0 \\
& x=369.87 \cos 32^{\circ}=313.67
\end{aligned}
$$

Magnitude of reaction $=\sqrt{147^{2}+313.67^{2}}=346 \mathrm{~N}(3$ s.f.)

$\tan \alpha=\frac{147}{313.67}$
$\alpha=25^{\circ}$ (to nearest degree)
The reaction of $A$ is at $25^{\circ}$ above the horizontal.

