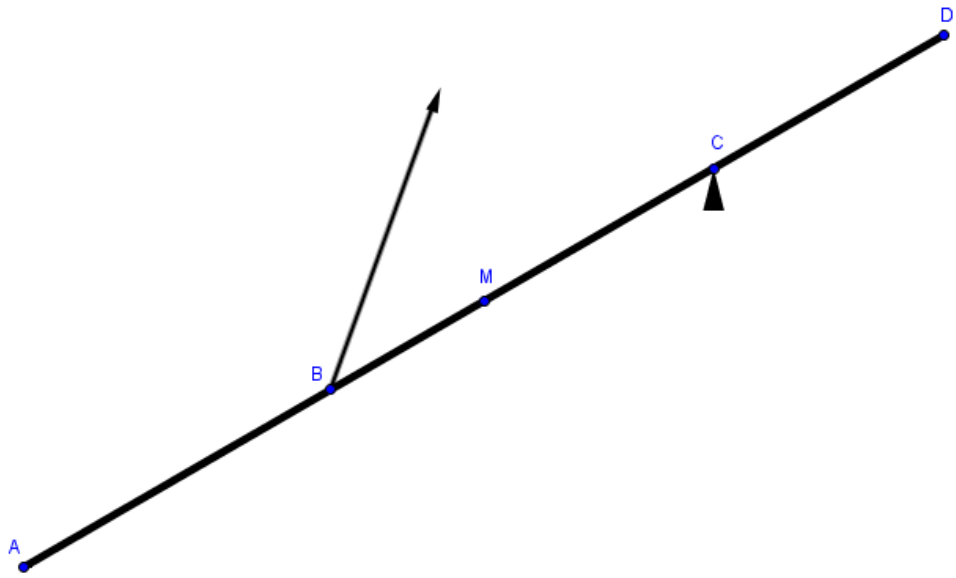
Sleeper Moment

A 6m long sleeper of mass 200kg is being held in equilibrium balanced on a point 1.5m from one end and held by a chain 2m from the other end. The sleeper is inclined at an angle of 30° *to the horizontal, and the chain is inclined at an angle of* 20° *to the vertical.*

Annotate the diagram fully. Show forces acting on the sleeper, distances and angles:



Calculate the tension in the chain, and, given that the sleeper is on the point of slipping, determine the coefficient of friction between the sleeper and the support.

Sleeper Moment SOLUTIONS

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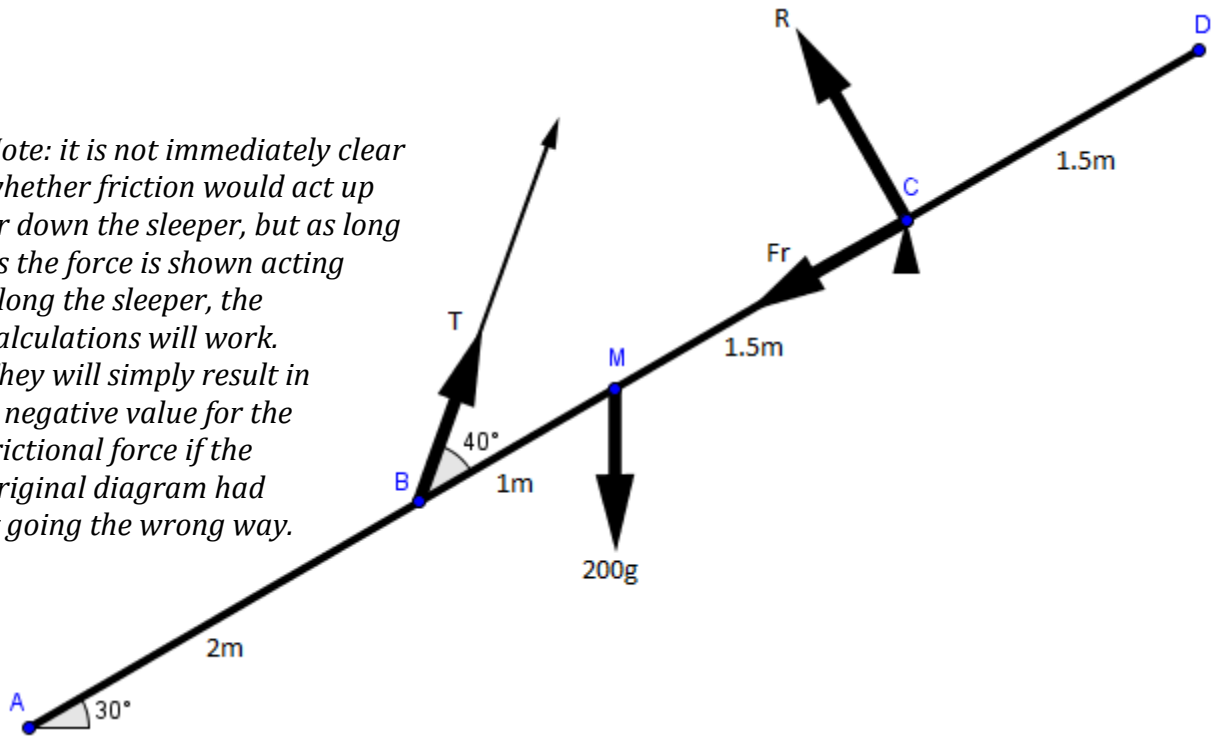
Annotate the diagram below fully, showing all forces acting on the sleeper:

Note: it is not immediately clear whether friction would act up or down the sleeper, but as long as the force is shown acting along the sleeper, the calculations will work. They will simply result in a negative value for the frictional force if the original diagram had it going the wrong way.



Calculate the tension in the chain, and, given that the sleeper is on the point of slipping, determine the coefficient of friction between the sleeper and the support.

To find the tension, take moments about C (eliminating R and F_r):

$$T \sin 40 \times 2.5 = 200g \cos 30 \times 1.5$$

$$\Rightarrow \quad T = \frac{300g \cos 30}{2.5 \sin 40} = \mathbf{1584.42N\ to\ 2\ d.p.}$$

To find the coefficient of friction, take moments about B to find R:

$$2.5R = 200g \cos 30 \quad \Rightarrow \quad R = \frac{200g \cos 30}{2.5} = 678.96N \text{ to } 2\ d.p.$$

Then resolve along the length to find F_r:

$$F_r + 200g \sin 30 = T \cos 40 \quad \Rightarrow \quad F_r = 1584.42 \cos 40 - 200g \sin 30 = 233.74N \text{ to } 2\ d.p.$$

And use the formula for limiting equilibrium to find μ:

$$F_r = \mu R \quad \Rightarrow \quad 233.74 = 678.96\mu \quad \Rightarrow \quad \mu = \frac{233.74}{678.96} = \mathbf{0.34\ to\ 2\ d.p.}$$