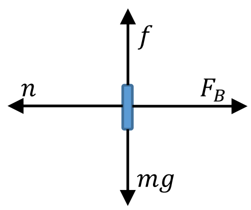
110fa22t3aSoln

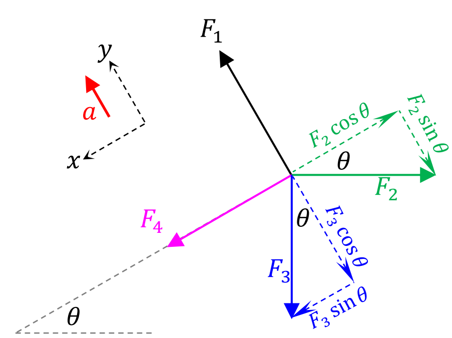
1abcd) **The car and tree exert equal magnitude forces on each other for both scenarios.**
According to Newton's 3rd law, the force exerted by the tree on the car during the collision is equal in magnitude (but opposite in direction) to the force exerted by the car on the tree.
Newton's 3rd law is valid regardless of the acceleration state or the masses involved.

2a) The FBD looks like this:



2b) **ACTION:** The *earth* exerts a *gravitational* force *downwards* on the *magnet*.
REACTION: The *magnet* exerts a *gravitational* force *upwards* on the *earth*.

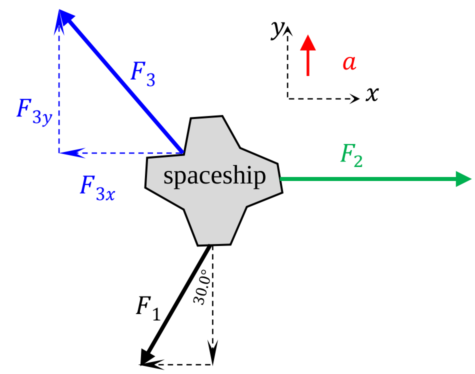
3) I've shown the forces split into components in the FBD at right.
Remember, this questions asked you to use the provided coordinate system.
You were also required to plug in $a_x = 0$ and $a_y = a$.



$$\Sigma F_x: \quad F_4 + F_3 \sin\theta - F_2 \cos\theta = 0$$

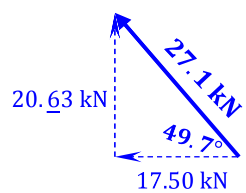
$$\Sigma F_y: \quad F_1 - F_3 \cos\theta - F_2 \sin\theta = ma$$

4) Initially, I wasn't sure which way to draw the final force.
I did know the *net* force must be directed upwards (since net force points in the direction of acceleration).
I notice the horizontal component of $\vec{F}_1$ (directed to the left) is smaller than $\vec{F}_2$ (all of it directed to the right).
From this I deduced the third force must point upwards and to the left.

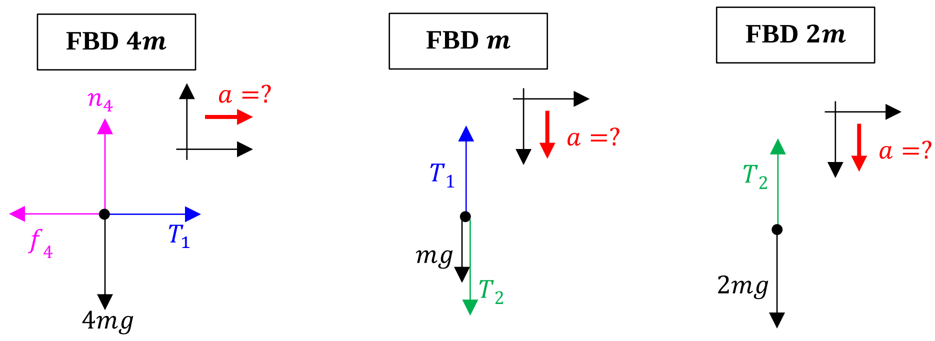


Cool trick to know: if you aren't sure which way to draw the unknown force, you can always draw that force however you want (usually one chooses positive x- and y-components). If for some reason you discover one of your components gives a negative result, that particular component is directed opposite the direction drawn!

$\Sigma \boldsymbol{F}_x$:	$F_2 - F_1 \sin 30.0° - F_{3x} = 0$ $F_{3x} = F_2 - F_1 \sin 30.0°$ $\boldsymbol{F_{3x} = 17.50\ \text{kN}}$
$\Sigma \boldsymbol{F}_y$:	$F_{3y} - F_1 \cos 30.0° = ma$ $F_{3y} = ma + F_1 \cos 30.0°$ $\boldsymbol{F_{3y} = 20.\underline{6}3\ \text{kN}}$



Problem 5 FBDs: Force arrows not to scale.



5a) To determine the *minimum* coefficient of friction required to prevent sliding, assume the system is on the verge of slipping. In this case we know $f_4 = \mu_s n_4$. Furthermore, in this scenario we also know that implies $a = 0$!
Using the FBDs above I found

$$3mg - f_4 = 0$$

$$3mg - \mu_s(4mg) = 0$$

$$\boldsymbol{\mu_{s\,min} = 0.750}$$

5b) If the frictional coefficients are $\mu_s = 0.555$ & $\mu_k = 0.444$, friction is insufficient to keep the blocks at rest.
In this scenario we use $f_4 = \mu_f n_4$. Furthermore, in this scenario we also know that implies $a \neq 0$!
Using the FBDs above I found

$$3mg - f_4 = 7ma$$

$$3mg - \mu_k(4mg) = 7ma$$

$$\boldsymbol{a = 0.1749g}$$

5c) You can use either FBD $4m$ or FBD m. Using the force equation from the $4m$ FBD:

$$T_1 - f_4 = 4ma$$

$$T_1 = 4ma + f_4$$

$$T_1 = 4m(0.1749g) + \mu_k(4mg)$$

$$\boldsymbol{T_1 = 2.48mg}$$