Answer on Question #56954-Physics-Mechanics-Relativity

In the figure above, a 20 kg boom of length 4.5 m is supported by a cable that has a breaking tension of 750 N. The cable is perpendicular to the boom and is attached 3.375 m from the pivot. Find:

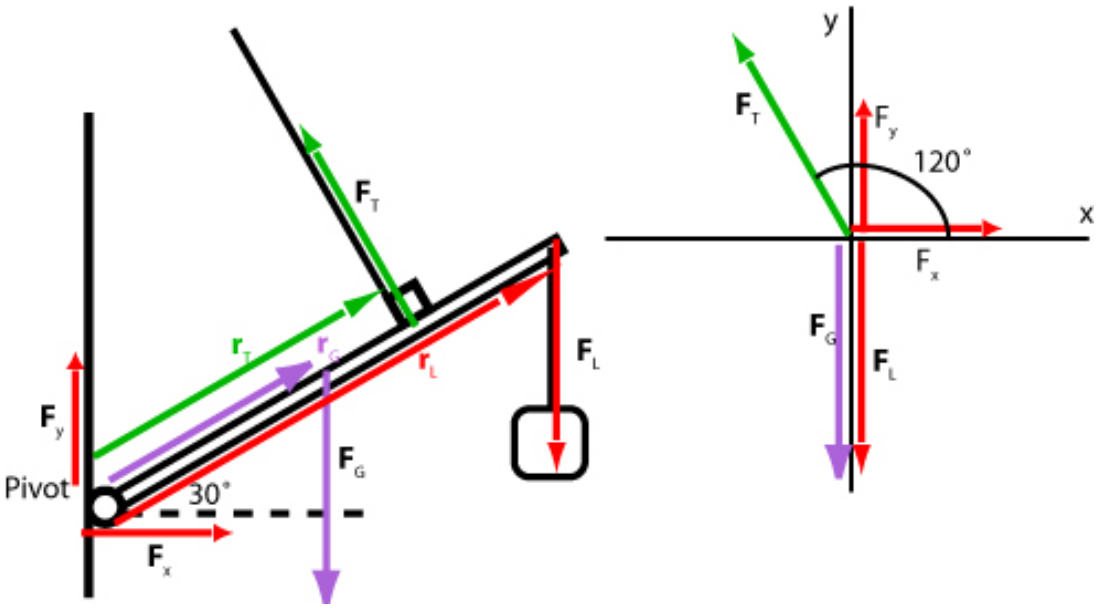
a) The maximum load that can be suspended from the end of the boom;

b) The magnitude of the vertical force exerted by the pivot at maximum load?

c) The magnitude of the horizontal force exerted by the pivot at maximum load?

Solution

To solve this problem we will assume that the tension in the cable is 750 N. We will begin with forces exerted on the boom: the weight F_G of the boom acts at the center of the mass 2 m from the pivot; the load F_L is a force acting downward (it is really tension in the wire from which the load is suspended) and it acts at a distance 4 m from the pivot; the tension F_T acts at a distance 3 m from the pivot; and finally, the force F exerted on the boom by the hinge is broken in the diagram below into two components F_x and F_y. Since the boom is in equilibrium we are free to choose the axis as shown in the diagram. Note that we have colour coded each force and its arm lever.



The boom is in equilibrium and therefore

$$\sum F_x = 0, \sum F_y = 0, \sum \tau = 0$$

We will begin by computing the components of each of the forces:

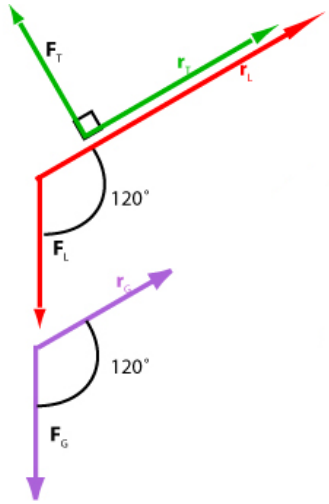
Forces	x-component	y-component
F_G	0	-196 N
F_L	0	$-F_L$
F_T	7500 cos(120°) = -3750 N	750 sin(120°) = 650 N

F	F_x	F_y
ΣF	0	0

We can solve the equation for the x-components and write

$$F_x = 650\ N$$

but we cannot solve the equation for the vertical components of the forces. We need to compute the torques and then use the fact that the net torque is zero.



Forces	$\tau = -(4)F_L \sin 120^\circ = -3.46F_L$
F	0
F_T	$\tau = (3.375)(750) = 2531\ Nm$
F_G	$\tau = -(2.25)(196)\sin 120 = -382Nm$
F_L	$\tau = -(4.5)F_L \sin 120 = -3.90\ F_L$
$\Sigma\tau$	0

Solving the equation we find

$$F_L = \frac{2531 - 382}{3.90} = 551\ N.$$

Then we can solve the equation for the y-components to find

$$F_y = 551 + 196 - 650 = 97\ N.$$

Answer: a) $551\ N$; b) $97\ N$; c) $650\ N$.