Quizbit 6 Solution

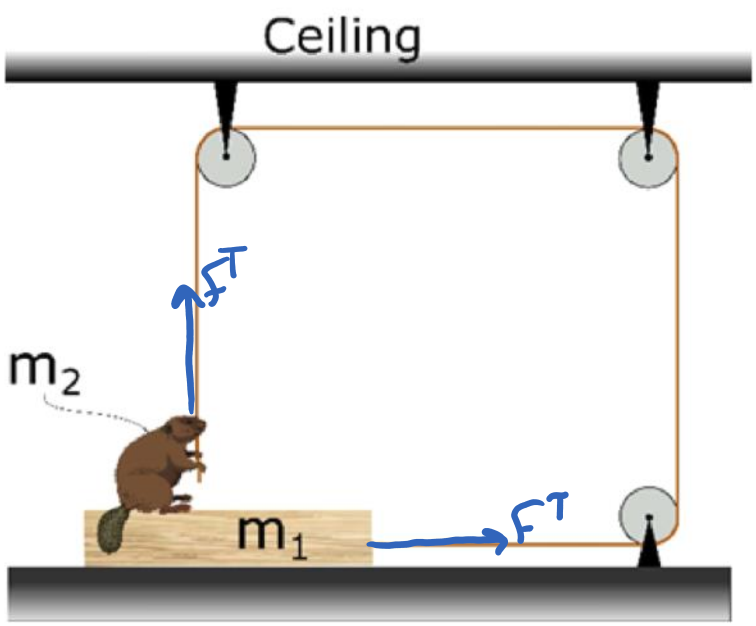
Thursday, November 3, 2022 2:21 PM

Individual Quizbit 6

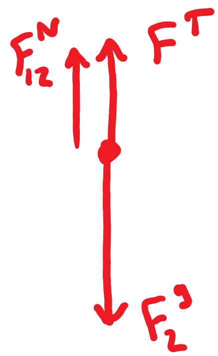
PH201, Fall 2022

You are encouraged to discuss these questions with others, but those conversations need to be only in words. Please do not write down steps for others, draw pictures, show math steps, or consult online resources. Any work shown here should be your own thoughts and not copied from any source. You will be graded on the clarity of how well you communicate your steps and reasoning, not on absolute correctness. Hand write your solutions (paper or tablet) and turn your work into Grad-escope.

Problem Statement | After taking a physics course, Benny the beaver constructed a device as shown below. Benny is initially on top of the box m_1. There is friction between the box m_1 and the surface that it rests on. Benny is wearing his low-friction boots so there is negligible friction between Benny and the box m_1. Benny's mass is $\mathbf{m_2 = 20\ kg}$, the box's mass is $\mathbf{m_1 = 30\ kg}$, and the coefficients of friction between the box and the floor are $\mu_k = \mathbf{0.11}$ and $\mu_s = \mathbf{0.30}$. What is the maximum force that Benny can pull down on the rope with before the box m_1 begins to slide?



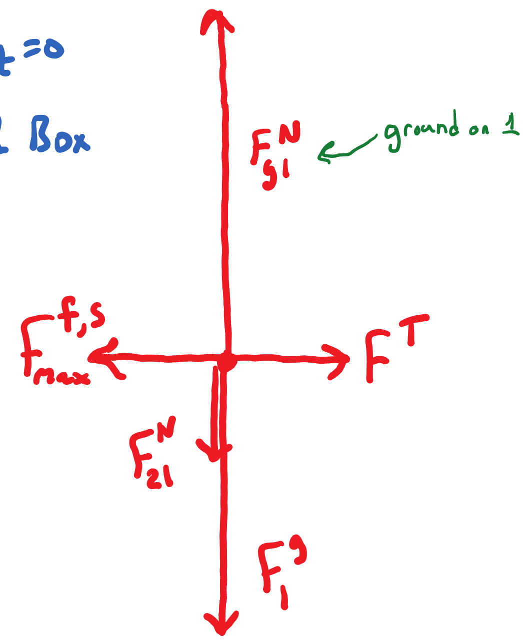
FBD of Benny



$\vec{a} = 0 \Rightarrow \vec{F}_{net} = 0$

for Benny & Box

FBD of Box



$\Sigma f_y = m a_y$

$F^N_{12} + F^T + F^g_2 = m \cancel{a_y}^{0}$

$|F^N_{12}| + |F^T| - m_2 g = 0$

(1) $|F^N_{12}| = m_2 g - |F^T|$

y/ $\Sigma f_y = m a_y$

$|F^N_{g1}| - |F^g_1| - |F^N_{21}| = m \cancel{a_y}^{0}$

(2) $|F^N_{g1}| = m_1 g + |F^N_{21}|$

x/ $\Sigma f_x = m a_x$

$|F^T| - |F^{f,s}_{max}| = m \cancel{a_x}^{0}$

(3) $|F^T| - \mu |F^N_{g1}| = 0$

Connecting relationships (aka algebra :))

Since $|F_{12}^N| = |F_{21}^N|$, we can plug ① into ②

& get :

$$|F_{21}^N| = m_1 g + m_2 g - |F^T|$$

$$③ \Rightarrow |F^T| - \mu\left(m_1 g + m_2 g - |F^T|\right) = 0$$

$$\Rightarrow |F^T| - \mu|F^T| - \mu g(m_1 + m_2) = 0$$

$$\Rightarrow |F^T|(1-\mu) = \mu g (m_1 + m_2)$$

$$\Rightarrow |F^T| = \left(\frac{\mu}{1-\mu}\right)(m_1 + m_2) g$$

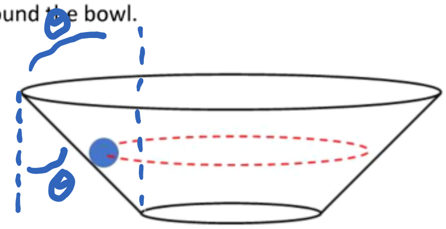
Since this is evaluated at max value of static friction, this is the largest F^T value before block slides.

Group Quizbit 6

PH201, Fall 2022

You will be working with your group to create a single solution for these questions. You are encouraged to think about the questions beforehand, and discussing with your classmates is encouraged, but do not bring a solution to your group's working session. You are working to develop a shared solution, with the input and problem solving skills of all your group members. You will be graded on both the clarity of how well you communicate your steps and reasoning, and on absolute correctness.

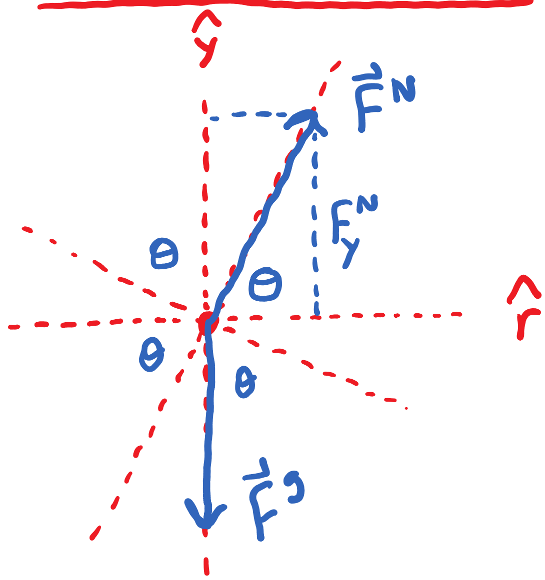
Problem Statement | A marble travels in a circular path of radius **R** at a constant speed and height around the inside of a bowl, as pictured. The bowl and marble are on a planet with an unknown value of **g**. The friction between the side of the bowl and the marble is negligible. The side of the bowl makes an angle, **θ,** with respect to the vertical and the marble takes **T** seconds to make one full rotation around the bowl.



(a) Find an expression for the radius, **R**, of the marble's path around the bowl in terms of numbers, **π**, **T**, **θ,** and **g** only. *(hint: notice that the mass of the marble, m, does not appear in this statement! Hint 2: an example answer is R = 3π g sin(θ) / T, this is* ***not*** *the correct answer!)*

(b) Do the units or dimensions of your answer match what you expect them to be? Explain.

a) force analysis



y: $\sum F_y = m a_y$

$$F_y^N + F^g = m a_y^{\;0}$$

$$|F^N| \sin\theta - mg = 0$$

$\hat{r}$: $\sum F_r = m a_r$

$$F_r^N = m a_r$$

$$|F^N| \cos\theta = m a_r$$

Connecting r & y

(y) $\Rightarrow |F^N| = \dfrac{mg}{\sin\theta}$

(r) $\Rightarrow \left(\dfrac{mg}{\sin\theta}\right)\cos\theta = m a_r$

$$\Rightarrow \frac{g}{\tan\theta} = a_r$$

$a_r = \dfrac{v^2}{r}$ because UCM

$$\Rightarrow \frac{g}{\tan\theta} = \frac{v^2}{r}$$

but what is $|v|$?

1 rotation in T seconds

$$\Rightarrow |v| = \frac{\text{distance}}{\Delta t} = \frac{2\pi r}{T}$$

$$\Rightarrow \frac{g}{\tan\theta} = \frac{\frac{4\pi^2 r^2}{T^2}}{r}$$

$$\Rightarrow \frac{g}{\tan\theta} = \frac{4\pi^2 r}{T^2} \Rightarrow \boxed{R = \frac{T^2 g}{4\pi^2 \tan\theta}}$$

b) Sensemaking!

$$[R] = \text{meters}$$

$$\left[\frac{T^2 g}{4\pi^2 \tan\theta}\right] = \frac{(\text{sec})^2 \frac{m}{(\text{sec})^2}}{\text{zilch}} = m$$

these match!