

HW Solutions 3 - 8.01 MIT - Prof. Kowalski

Topics: circular and relative motion and Newton's first two laws.

1) 4.4

Please refer to figure 4.26 p.148.

This is just a vector algebra problem and the problem is not interested in dynamics. The vector here is the force!

a) $F_x = F \cos \theta$ where θ is the angle that the rope makes with the ramp ($\theta = 30^\circ$ in this problem), so $F = |\vec{\mathbf{F}}| = \frac{F_x}{\cos \theta} = \frac{60}{\cos 30^\circ} = 69.3 \text{ N}$.

b) $F_y = F \sin \theta = F_x \tan \theta = 34.6 \text{ N}$.

c) The problem in part **a** and **b** is not interested in the force along or perpendicular to the ground. So, as long as we don't change the angle with respect to the ramp the answer to part **a** and **b** would not change.

d) F makes an angle 50° with respect to ground so the F_{gx} and F_{gy} is derived from:

$$F_{gx} = F \cos \theta_g = 69.3 \times \cos 50^\circ = 53.1 \text{ N}.$$

$$F_{gy} = F \sin \theta_g = 69.3 \times \sin 50^\circ = 44.5 \text{ N}.$$

2) 4.30

a) v_{ave} between two points, e.g. f and i, for a constant acceleration is $v_{ave} = \frac{v_f + v_i}{2}$. Here $v_f = 0 \Rightarrow v_{ave} = \frac{v_0}{2}$.
The stopping time is $t_s = \frac{x}{v_{ave}} = 2 \frac{0.130}{350} = 7.43 \times 10^{-4}$ s.

b) $\vec{a} = \frac{v_0}{t_s}(-\hat{x})$ where \hat{x} is the direction of motion.
 $\vec{F} = m\vec{a} = 1.80 \times 10^{-3} \frac{350}{7.43 \times 10^{-3}}(-\hat{x}) = -848\hat{x}$

c) using $v_y^2(t) - v_y^2(t_0) = +2a_y[y(t) - y(t_0)]$ we get
 $\vec{a} = \frac{350 \times 350}{2 \times 0.130}(-\hat{x}) = -0.47 \times 10^6 \hat{x}$.

3) 4.25

The train accelerates the **eastward** direction. So the acceleration \vec{a} is east, which is \hat{x} in the figure. Because the ball is at rest in the train its net acceleration in an inertial (non-accelerating) frame is just the \vec{a} .

So according to Newton's $\vec{F} = m\vec{a}$ vector law, the net forces in x direction should be positive.

Pay attention to the fact that this law should be written in the rest frame so writing this law in the train frame is **NOT** allowed because the train accelerates.

The next step is to analyze the forces to see in which configuration Newton's law will be fulfilled. The only forces present in this problem is gravity \vec{W} and tension \vec{T} .

We should see in which configuration we get a net force in +x direction. Since gravity has no component in x direction the analysis is simple and the direction of \vec{T} will tell us the direction in which direction the ball accelerates as shown in the figure.

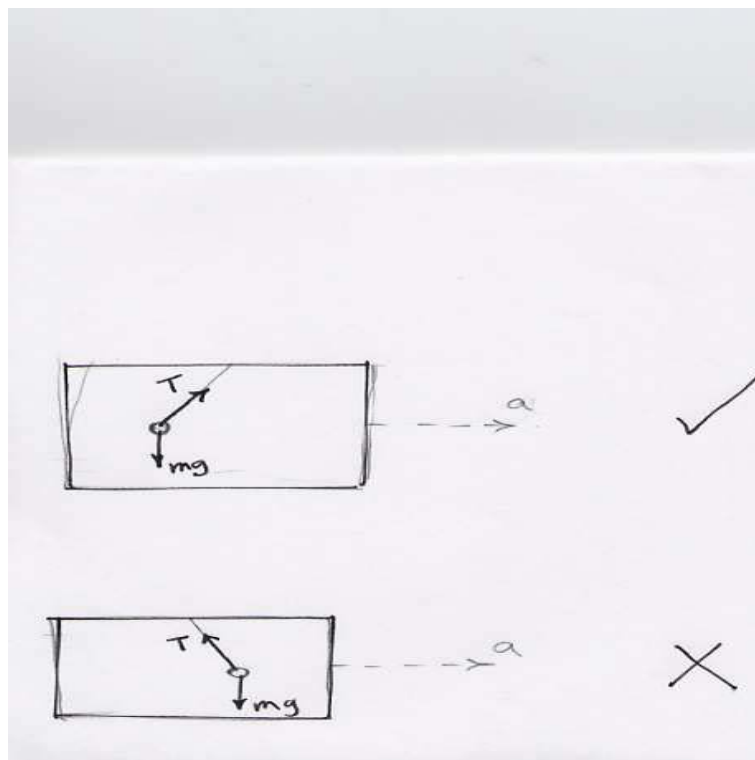


Figure 1: 4.25

4) 5.98

The lunch box is at rest in the bus frame so it is moving with the **same** \vec{v} as the bus.

The analysis of this problem is similar to **example 5.22**. So make sure first that you have understood that example.

Using the free body diagram I write Newton's second law in the direction toward center and the direction perpendicular to ground and certainly in *an inertial frame*.

There are only two forces present We have:

\vec{T} and $m\vec{g}$. In the inertial frame there is no motion in the direction \perp to the plane of rotation.

$$a_{\perp} = 0 \Rightarrow T \cos \theta = mg \Rightarrow T = \frac{mg}{\cos \theta}$$

We have a central acceleration $a_c = \frac{v^2}{R}$ for the circular motion and the only force that has component in the central direction is T with $T_c = T \sin \theta = ma_r = m \frac{v^2}{R}$.

$$T \sin \theta = mg \tan \theta = m \frac{v^2}{R}$$

$$\Rightarrow v = \sqrt{gR \tan \theta} = 17m/s = 17 \frac{0.62 \times 10^{-3}}{60 \times 60} \simeq 38 \text{ mph}$$

rotate your figure please!

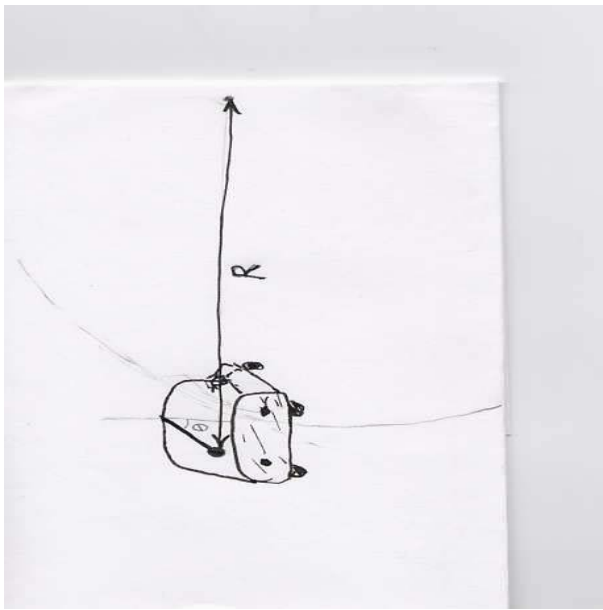


Figure 2: 5.98

5) **4.39**

The constraint in this problem is the fact that the rope does not **stretch** or **shrink**. So the acceleration $\vec{\mathbf{a}}_L$ of mass 4.00 kg should be equal to the acceleration $\vec{\mathbf{a}}_R$ of mass 6.00 kg. It's also clear that there is no acceleration in y direction so the gravity is being cancelled by the normal force from the ground.

a) $\vec{\mathbf{a}}_L = \vec{\mathbf{a}}_R = 2.50 \text{ m/s}^2 \hat{\mathbf{x}}$.

From the free body diagram we see:

b) The only force that causes $\vec{\mathbf{a}}_L$ is $\vec{\mathbf{T}}$. Writing $\vec{\mathbf{F}} = m\vec{\mathbf{a}}$ in the x direction for both masses we have: $T = m_L a_L = 4.00 \times 2.50 = 10.00 \text{ N}$.

c) The net force acting on the right block is just $\vec{\mathbf{F}}_R = m\vec{\mathbf{a}}_R = 6.00 \times 2.50 \hat{\mathbf{x}} = 15.0 \text{ N } \hat{\mathbf{x}}$. Particle is accelerating to the **Right** so $F > T$.

d) Free body diagram for the right object: $a_R = \frac{F-T}{m_R} \Rightarrow F = m_R a_R + T = 25.0 \text{ N}$.

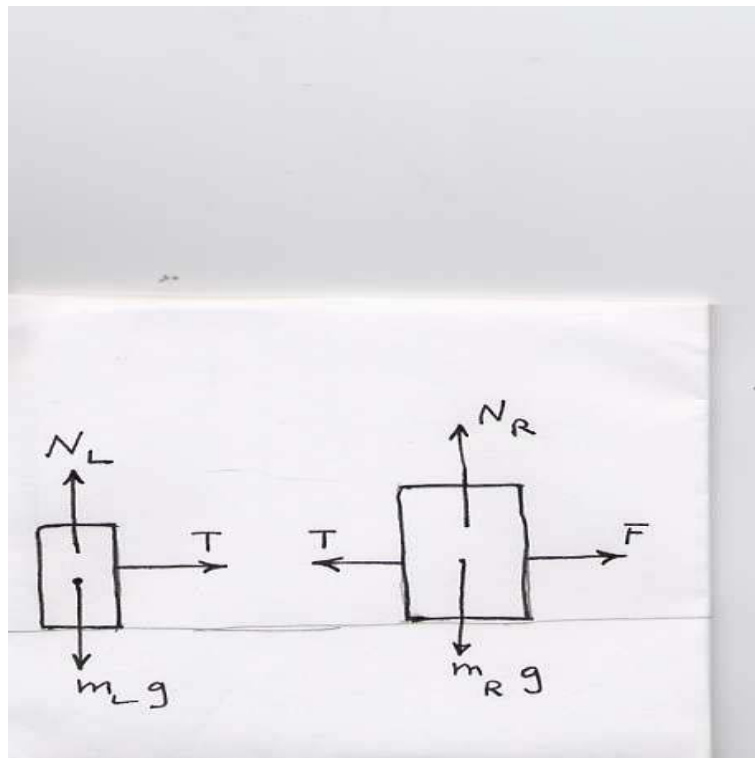


Figure 3: 4.39