Sample Exam II Solutions

MC1) (A)

For the lower mass: $+T_2 - gm_L = m_L a \rightarrow T_2 = gm_L + m_L a = 10(5) + 5(-3) =$ 35 N

For the upper mass: $+T_1 - T_2 - gm_U = m_U a \rightarrow T_1 = T_2 + gm_U + m_U a = 35 + 10(10) + 10(-3) =$ 105 N.

OR you could treat the two masses as one: $+T_1 - g(m_U + m_L) = (m_U + m_L)\,a \rightarrow T_1 = (a + g)(m_U + m_L)$ $= (-3 + 10)(10+5) =$ 105 N.

MC2) (D)

(A) Is possible, but it's not a necessary condition. (B) Third law forces act on different objects, and so can not cancel each other out. (C) This has nothing to do with the question. (D) This is the correct response, since NII says that if a = 0, then ΣF = 0. (E) has many counter examples, for instance an object at rest on an incline.

MC3) (D)

First, let's assume that there is in fact a correct answer listed. Let's see if we can suss out the correct choice without trying to write the equations from scratch. If the block is about to slide to the right, the frictional force will be to the left. We need an equation where the component of the applied force and the frictional force have opposite signs. This eliminates (A) and (B) regardless of whether the choice of sine or cosine is correct. Similarly, the normal force and the weight are both down, so we need an equation where they have the same signs; this eliminates (A), (C), and (E). This leaves (D) as the only possibly correct answer.

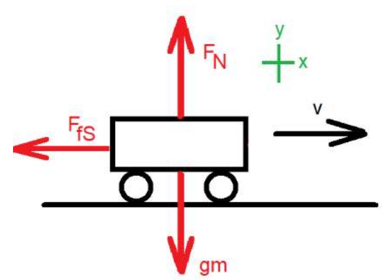
MC4) (B)

The weight of the satellite is the centripetal force and equals gm, since the satellite is at the surface of the earth. Then,

$$+gm = ma_C = m\frac{v^2}{r} \quad \rightarrow \quad v = \sqrt{gr} = \sqrt{10(6{,}400000)} = 8000\,\mathrm{m/s}\,.$$

MC5) (D)

We assume no skidding. If the car skids, the friction would be kinetic and therefor less than the non-skidding static case.



Write NII equations:

$$x:\; -F_{fS} = ma_x$$

$$y:\; +F_N - gm = ma_y = 0$$

$$F_{fS} = \mu_S F_N \;\; \text{(crit sit)}$$

Then,

$$\mu_S = \frac{F_{fS}}{F_N} = \frac{-ma_x}{gm} = \frac{-a_x}{g} = \frac{-(-11.1)}{10} = 1.1$$

PROBLEM I

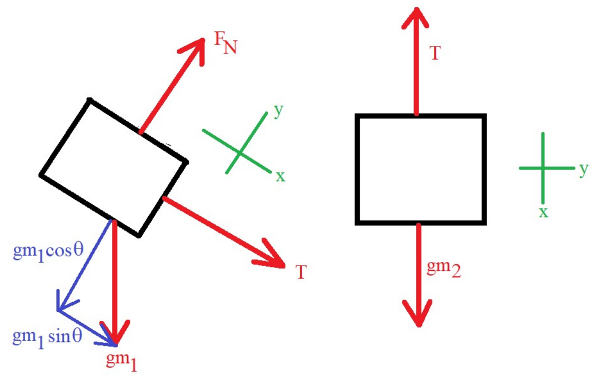
Since there is acceleration, follow Rule Nr 1.
Use the fractured coördinate system shown.
Then, write the NII equations:

$$M_1 \quad x: \ +T + gM_1\sin\theta = M_1 a_x$$

$$M_1 \quad y: \ +F_N - gM_1\cos\theta = M_1 a_y = 0$$

$$M_2 \quad x: \ -T + gM_2 = M_2 a_x$$

$$M_2 \quad y: \quad \text{No Forces}$$



Add the two x equations:

$$+T + gM_1\sin\theta - T + gM_2 = M_1 a_x + M_2 a_x$$

$$gM_1\sin\theta + gM_2 = (M_1 + M_2)a_x$$

$$a_x = \frac{M_1\sin\theta + M_2}{M_1 + M_2} g = \frac{2\left(\frac{1}{2}\right) + 5}{2 + 5} 10 = 8.57 \text{ m/s}^2$$

Substitute back into the M_2 x equation:

$$T = gM_2 - M_2 a_x = 10(5) - 5(8.57) = 7.15 \text{ N}$$

PROBLEM II

Let downstream be the + direction. Let W = water, B = boat, and G = ground. We have that

$$v_{B,G} = v_{B,W} + v_{W,G} \quad .$$

A) Downstream, we have

$$v_{B,G} = v_{B,W} + v_{W,G} = +3 + 1 = 4 \text{ m/s} \ .$$

$$v_{B,G} = \frac{\Delta x_{B,G}}{t} \quad \rightarrow \quad t = \frac{\Delta x_{B,G}}{v_{B,G}} = \frac{+2000}{4} = 500 \text{ seconds} \quad .$$

B) He has 3600 – 500 = 3100 seconds left.

C) Now, find $v_{B,W}$ so that he makes it back in time.

$$v_{B,G} = \frac{\Delta x_{B,G}}{t} = v_{B,W} + v_{W,G}$$

$$v_{B,W} = v_{W,G} - \frac{\Delta x_{B,G}}{t} = -1 - \frac{-2000}{3100} = -0.35 \text{ m/s}.$$

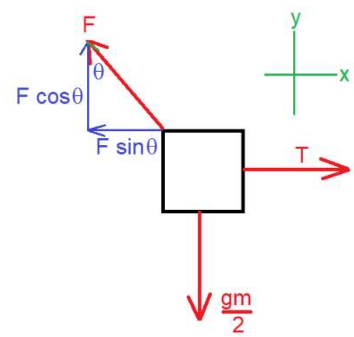
This is well below the boat's speed of -3 m/s, so yes, he will make it back with time to spare.

PROBLEM III

Buzz might throw his hammer in a direction exactly opposite to the direction to the ship. Since he exerted a force on the hammer, by the third law, the hammer exerted an opposite force on him, accelerating him toward his ship.

PROBLEM IIII

Consider the left half of the string. There is a force F on the string from the pole, there is the weight of the half string (gm/2), and there is the tension (T) on the left half at the center of the string that we're trying to find.



NII:

$$x:\ \ +T - F\sin\theta = \frac{m}{2}a_x = 0$$

$$y:\ -g\frac{m}{2} + F\cos\theta = \frac{m}{2}a_y = 0$$

Re-arrange and divide the equations:

$$T = F\sin\theta$$

$$g\frac{m}{2} = F\cos\theta$$

$$\frac{T}{g\frac{m}{2}} = \tan\theta \quad \rightarrow \quad T = \frac{gm\tan\theta}{2}$$