(a) Draw Three Separate Free body Diagrams showing the forces acting on A, B, and C.

Block A should contain (tension, gravitational, Normal, and Frictional) forces
Block B should contain (tension, gravitational, Normal, and Frictional) forces
Block C should contain (tension, gravitational,) forces

(b) Find the Tension in the rope connecting Blocks A and B.

The current problem is an exercise in Sum of Forces.($\Sigma F = ma$) By summing the forces on each block, the answers to part (b) and (c) fall out of the equations easily. Start by summing the forces on Block A in the direction of the pully. Subscripts (A,B,C) denote block. Subscript (T, N, g, and f) denote (Tension, Normal, gravitational, and frictional) forces respectively.

$\Sigma F_{xA} = m_A a_A$

$F_{TAB} - F_{fA} = m_A a_A$ - Since the system is moving at a constant velocity, a = 0.

$F_{TAB} - (25N * 0.35) = 0$

$\boldsymbol{F_{TAB} = 8.75N}$

(c) What is the weight of Block C?

Intuitively, let is first examine Block C.

$\Sigma F_{xC} = m_C a_C$

$F_{gC} - F_{TBC} = m_C a_C$ - Since the system is moving at a constant velocity, a = 0.

$F_{gC} = F_{TBC}$ - The weight is equal to the tensional Force

As we don't know (F_{TBC}), let us do a Sum of forces for Block B.

$\Sigma F_{xB} = m_B a_B$

$F_{TBC} - F_{TAB} - F_{fB} - \sin(32) * F_{gB} = m_B a_B$ -Again, a=0

$F_{TBC} - 8.75N - \cos(32) * 0.35 * 25N - \sin(32) * 25N = 0$

$F_{TBC} = 29.4\ N$

Therefore, $\boldsymbol{F_{gC} = 29.4\ N}$

(d) If the rope connecting Blocks A and B were cut, what would be the accerleration of Block c?

This Question is very similar to the last part of Problem 4 in Problem Set 2. We have a system in equilibrium in which there is no acceleration. The rope between Block A and B is cut. This effectively eliminates the F_{TAB} force.. Consider the new sum of forces on Block B in which $F_{TAB} = 0$ and $a \neq 0$.

$F_{TBC} - F_{fB} - \sin(32) * F_{gB} = m_B a_B$

$F_{TBC} - \cos(32) * 0.35 * 25N - \sin(32) * 25N = m_B a_B$ - If $F_g = mg$ then $m = F_g / g$

$F_{TBC} - \cos(32) * 0.35 * 25N - \sin(32) * 25N = \frac{25N}{g} a_B$ (Don't know F_{TBC} or a_B)

New Sum of forces on Block C

$F_{gC} - F_{TBC} = m_C a_C$

$29.4N - F_{TBC} = \frac{29.4N}{g} a_C$ (Don't know F_{TBC} or a_C)

Since the blocks are connected, we know a_B = $a_C = a$. This leaves us with two equations and two unknowns. Rearranging the sum of forces for Block C…

$$F_{TBC} = 29.4N - \frac{29.4N}{g}a$$

Plugging this value into the sum of forces equation for block B allows us to solve for the acceleration.

$$29.4N - \frac{29.4N}{g}a - \cos(32) * 0.35 * 25N - \sin(32) * 25N = \frac{25N}{g}a$$

$$\boldsymbol{a = 1.57\frac{m}{s^2}}$$

This is a problem dealing with Work that does not require integration

$W_T = W_1 + W_2$

$W_1 = F_{1x} * d$ - Considering the component of F in the direction of motion

$W_1 = \cos(14°) * 1.8 * 10^6 N * 750m$ - Distance in meters, not Km as given

$W_1 = 1.31 * 10^9 Nm$

Similarly,

$W_2 = 1.31 * 10^9 Nm$

$W_T = 1.31 * 10^9 Nm + 1.31 * 10^9 Nm$

$\boldsymbol{W_T = 2.62 * 10^9 Nm}$

Problem 3

In this problem, we examine the concept of Work in the presence of non-constant Force. The solution provide here makes use of integration (As shown in lecture 4 or 5). For those students who are not strong in calculus, this problem can also be solved graphically by plotting the Force as a function of x and computing the area under the curve. It may be beneficial to present the graphical solution as well if time permits.

$F = -\propto x \ \ \hat{x}$ -The force is a function of x and acts in the x-direction.

$$\propto = 12\frac{N}{m}$$

Work is calculated as such…

$W = \int F\, dx$

$W = \int_{x1}^{x2} -\propto x \ dx$

$W = -\frac{1}{2} \propto x^2 \mid_{x1}^{x2}$

(a) How much work is done if the particle moves from (0.10m, 0m) to (0.10m, 0.40m)?

Coordinates provide an (x,y) location of the particle. As there is no change in the x position, we expect work to be zero.

$$W = -\frac{1}{2} \propto 0.1^2 + \frac{1}{2} \propto 0.1^2$$

$\boldsymbol{W = 0}$

(b) How much work is done if the particle moves from (0.10m, 0m) to (0.30m, 0m)?

$$W = -\frac{1}{2} \propto 0.3^2 + \frac{1}{2} \propto 0.1^2$$

$\boldsymbol{W = -0.48\ Nm}$

(c) How much work is done if the particle moves from (0.30m, 0m) to (0.10m, 0m)?

$$W = -\frac{1}{2} \propto 0.1^2 + \frac{1}{2} \propto 0.3^2$$

$\boldsymbol{W = 0.48\ Nm}$

Since the force acts in the negative x-direction, a positive change in x-displacement results in negative work while a negative change in x-displacement results in positive work!

Problem 4

This is a fun problem that deals with conservation of kinetic and potential energy.

We assume that Tarzan starts with an initial velocity of zero such that all of his energy is potential. Let us also set height of zero potential energy to by the height of Tarzan at the bottom of his swing so that at this point his energy is kinetic.

Conservation of Energy:

$$E_1 = E_2 \qquad E = K + U \qquad K = \tfrac{1}{2}mv^2 \qquad U = mgh$$

$$mgh_1 = \frac{1}{2}mv_2^2 + mgh_2$$

If the length of the vine is 20m, angle 1 is 45 degrees, and angle 2 is 30 degrees.

$$h_1 = 20m - 20 * \cos(45)$$

$$h_1 = 5.86\, m$$

Similarly

$$h_2 = 20m - 20 * \cos(30)$$

$$h_2 = 2.68\, m$$

Plugging in we can solve directly for the velocity

$mg * 5.86\, m = \frac{1}{2}mv_2^2 + mg * 2.68m$ –Mass cancels out

$$v = 7.89\frac{m}{s} \quad or \quad 28.4\frac{km}{hr}$$

Fast! It would probably hurt if Tarzan swung at you going 28.4 km/hr =)