PHYS 121: Solutions to Written Homework #01
February 6, 2024

Note: this homework is worth **15 points** as follows:

Problem 1	0 points	Do Not Grade.
Problem 2	0 points	Do Not Grade.
Problem 3	4 points	4 Points total.
Problem 4	6 points	6 Points total.
Problem 5	4 points	4 Points total.

Problem 1: Two blocks, with given masses $m_1 = 14.29$ kg and $m_2 = 3.67$ kg sit on a frictionless surface. The blocks sit side-by-side in contact with each other. A **given applied external horizontal force** $F_{app} = 16.84$ Newtons is applied to the side of the first block of mass m_1 which in turn pushes against the second block of mass m_2. As a result, both blocks are accelerated.

- **Part (a):** Draw a little sketch that indicates what is going on here. We need to see the two blocks in your sketch. We need to see how they are positioned relative to each other. We also need to see any coordinate system you plan to use. Also write down a list of ***given parameters*** for this problem (there are three of these). Also draw **Free Body Diagrams** for each of the two blocks indicating ***all*** of the relevant forces on each block. Be sure your forces are properly labeled: Use the "On-due" system. For example, one of your forces should be labeled like this: $\vec{N}_{21}$ which means "the Normal force *on* Block 2 ***due*** to Block 1.

- **Part (b):** What is the acceleration for the two blocks that results? You can safely assume that the two blocks move together (Yes, yes you can. This is called a ***Kinematic Constraint***.) Explain your work.

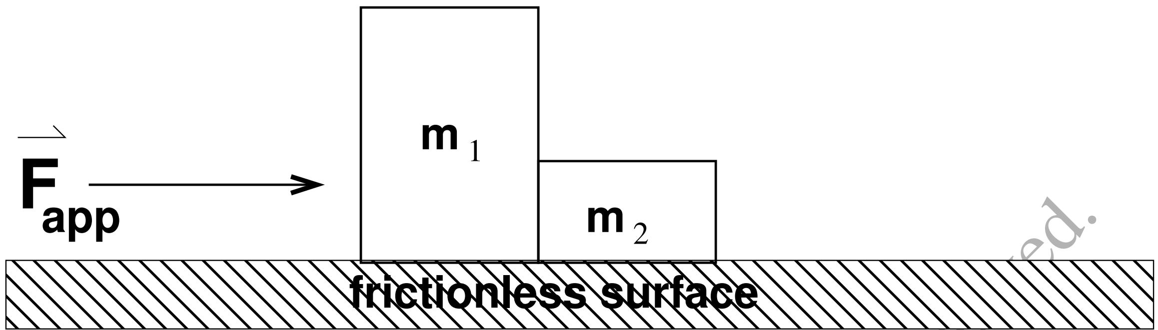
- **Part (c):** What is the magnitude of the Normal force exerted on Block 1 due to Block 2? Explain your work.

Important: As always, you **must** set up and solve this problem ***symbolically***, first and present your answer in terms of the given parameters which is an expression in terms of the given parameters: m_1, m_2, and F_{app}. Put a $\boxed{\text{box}}$ around your symbolic answers. After this is done, then plug in to get a numerical answer. Always plug in numbers only at the very end. Be sure your final answer has appropriate significant digits and units. Also be sure to put a $\boxed{\text{box}}$ around your final numerical answers.

Important: Please do *not* try to solve this problem by applying the concept of a "system" to the two blocks together. For this homework you are *obligated* to apply Newton's Second Law to each of the blocks separately and find the solution without using the concept of a 'system'. Thanks!

SOLUTION TO PROBLEM 1:

Let's start with a **clear sketch of the problem:** which is always helpful:



Since we are talking about forces here, this is good problem to consider using **Newton's Second Law**. But before we dive into the forces, and Free Body Diagram let's first reflect on the **acceleration**:

- The vertical acceleration of the blocks is obviously zero (because the blocks are constrained to move on the surface):

$$a_{1y} = a_{2y} = 0.$$

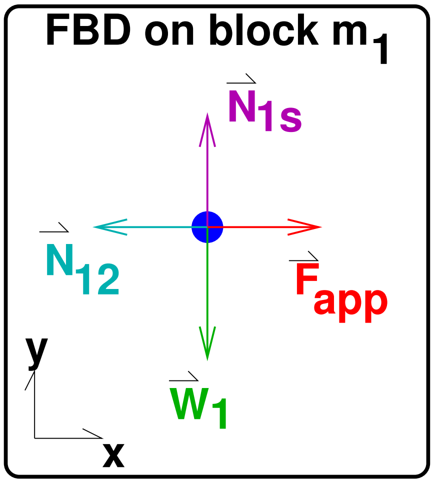
- Here horizontal the acceleration of the blocks is **not zero**. However the horizontal acceleration is also **not a given parameter**. We do not know the acceleration. In fact we are asked to calculate it.

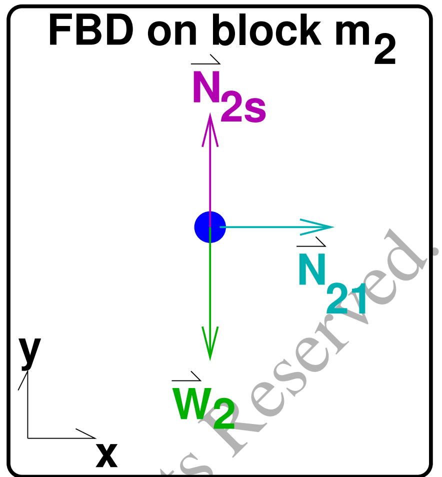
- Nonetheless, since the two blocks are side-by-side and ***moving together*** we can say that they have the ***same acceleration***. This is what we call a **Kinematic Constraint:** Let us define this unknown acceleration in the x-direction a.

$$a_{1x} = a_{2x} \equiv a \qquad \leftarrow \text{(this is a } \textbf{\textit{Kinematic Constraint}}.\text{)}$$

Solution continues next page....

Next, since we are applying Newton's Laws, we want to make clean, clear, **Free Body Diagrams** for each of the two blocks, showing all forces on each block:





Here are all of the forces on the left block, "Block m":

- Force $\vec{W}_1$, the force of *Weight* on block m_1.
- Force $\vec{N}_{1S}$, the *Normal* force on block m_1 due to the frictionless surface.
- Force $\vec{F}_{app}$, the *known applied external force* on block m_1.
- Force $\vec{N}_{12}$, the *Normal* force on block m_1 due being in contact with block m_2.

Here are all of the forces on Block m_2:

- Force $\vec{W}_2$, the force of *Weight* on block m_2.
- Force $\vec{N}_{2S}$, the *Normal* force on block m_2 due to the frictionless surface.
- Force $\vec{N}_{21}$, the *Normal* force on block m_2 due being in contact with block m_1.

Note that in particular, F_{app} is a force on block m_1 *only* and does *not* apply to block m_2.

Before we jump right in with Newton's Second Law, we note that none of the vertical forces here come into play in answering any of the questions as posed. All we are interested in are ***horizontal forces and motion***. So we are not going to worry about calculating any the vertical forces here, since we are not asked to do so.

Note also that we have defined the "positive horizontal" direction in terms of the position x, the same way as the positive acceleration of the system. Of course you are free to solve any problem using any coordinate system you choose, and you are guaranteed to get the same *physical* answer in the end. But as a rule, some choices for coordinate systems are much less cumbersome than others, and if we deliberately ***choose a coordinate system so that at least one of your coordinates is lined up with the direction of acceleration, this is almost always a good selection.***

So let's go: We work **Newton's Second Law**, Body "m_1", in horizontal direction:

$$F_{1x} = m_1 a_{1x}$$

Here $a_{1x} = a$ the as-yet-unknown acceleration of each block. It's worth emphasizing here again that F_{1x} is *not* a force. It is the *net force* on block m_1 in the x-direction.

For the right hand side of the equation, we Starting with the *left hand side*, we look to the FBD for block m and read off the two horizontal forces, one contributing in the positive-x direction, and one in the negative-x direction:

$$F_{app} - N_{12} = m_1 a \tag{1}$$

Right away, however, we see that this is about as far as we can go at this point, unfortunately. There are two terms, N_{12} and a, that are both *unknown*, but we've only written down one equation. We cannot solve two unknowns with only one equation. We are done. There is no further purpose to doing any additional algebra with this equation for now. We **stop.**

So next, we move on to work **Newton's Second Law**, Body "m_2", in horizontal direction:

$$F_{2x} = m_2 a_{2x}$$

Here $a_{2x} = a$. Now, again, next dealing with the net force on *left hand side:*

$$N_{21} = m_2 a \tag{2}$$

Again this is one equation but two unknowns: N_{21} and a. **stop.**

So we are up to two equations but we have three unknowns: N_{12}, N_{21} and a. At this point, we apply **Newton's Third Law** which tells us that the force-pair between block m_1 and block m_2 must have the same magnitude:

$$N_{21} = m_2 a \tag{3}$$

Now we have *three* unknowns, N_{12}, N_{21}, and a – and *three* equations: Eq. (1), Eq. (2), and Eq. (3). We are *done* with the physics: ***the rest is just algebra.***

There is more than one correct way to work the algebra from this point. For example, we can plug our expression for N_{21} from Eq. (3) into Eq. (2) to get:

$$N_{12} = m_2 a$$

We we can plug this expression for N_{32} into Eq. (1) and solve for the unknown a as follows:

$$F_{app} - m_2 a = m_1 a$$

$$m_1 a + m_2 a = F_{app}$$
$$a(m_1 + m_2) = F_{app}$$

$$\boxed{a = \frac{F_{app}}{m_1 + m_2}} \tag{4}$$

This is our desired **symbolic solution** for the acceleration.

Now we plug this result for the acceleration into Eq. (2) to get the normal force:

$$N_{12} = m_2 \left(\frac{F_{app}}{m_1 + m_2} \right)$$

$$\boxed{N_{12} = N_{21} = F_{app} \left(\frac{m_2}{m_1 + m_2} \right)} \tag{5}$$

This is our desired **symbolic solution** for the Normal force .

We can plug the numerical values in at this point, if we want. For the acceleration:

$$a = \frac{16.84 \text{ N}}{14.29 \text{ kg} + 3.67 \text{ kg}}$$

$$\boxed{a = 0.938 \text{ m/s}^2}$$

Likewise for the Normal force, plugging in numbers:

$$N_{12} = 16.84 \text{ N} \left(\frac{3.67 \text{ kg}}{14.29 \text{ kg} + 3.67 \text{ kg}} \right)$$

$$\boxed{N_{12} = N_{21} = 3.44 \text{ Newtons}}$$

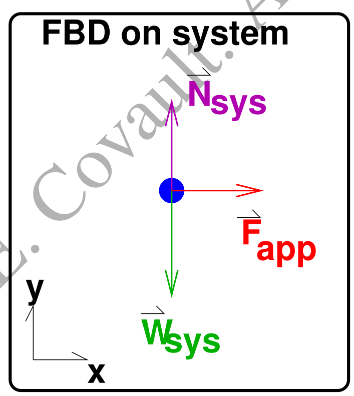
Solution continues next page....

Now that we have symbolic and numerical answers, it's worth looking more carefully at Eq. (5) to see how the normal force depends on the masses of the two bodies.

- In the limit that the large block is much more massive than the small block corresponding to $m_2 >> m_1$ the Normal force between the two objects grows in the limit to be the same as the applied force. This would correspond to hitting my hand with a hammer through a piece of paper, for example.

- In contrast, when $m_1 >> m_2$ the Normal force between the two objects goes to zero. This corresponds to trying to apply a hammer force to my hand through a lead brick. The more massive the intervening object, the more of the applied force that gets "used up" to accelerate it.

One final note on this problem. Several students tackled this problem by defining the two blocks moving together as one "object" or "system". This is certainly allowed, and the application of Newton's Second Law to such a **system of two objects** works fine because the two objects move together and so there is no question of what the acceleration is. To get the acceleration, we construct a **Free Body Diagram of the system-as-a-whole**. This approach to getting the acceleration is quite simple:



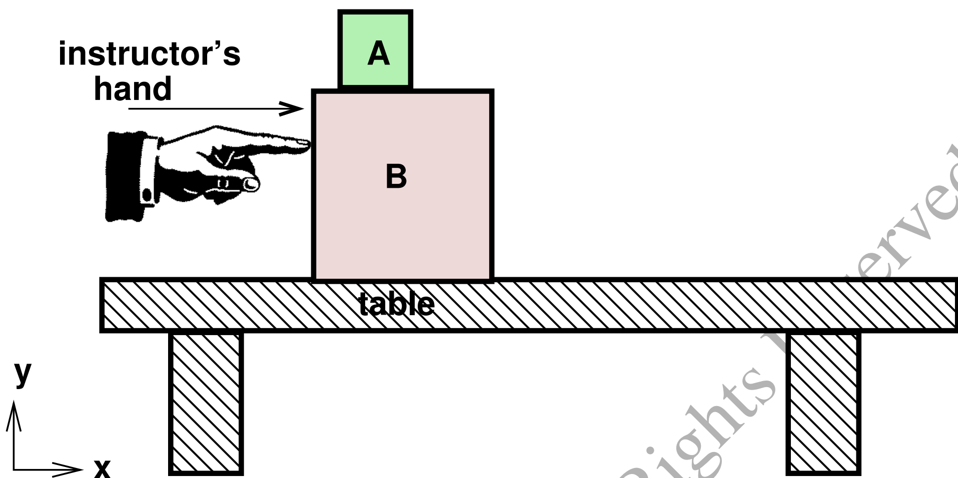
And applying **Newton's Second Law** to determine the acceleration is is quite easy:

$$F_{sys} = M_{sys}a$$
$$F_{app} = M_{sys}a$$
$$a = \frac{F_{app}}{M_{sys}}$$
$$a = \frac{F_{app}}{m_1 + m_2}$$

This is the same result as shown in Eq. (4) above. Indeed, if we were *only* interested in the acceleration of the system, this idea of defining a system would definitely be the quickest and cleanest way to solve the problem. But we also need to know the Normal force between the two blocks. Unfortunately, there is no way to deal with such a force if we treat the system as a whole as one body. This is because any "internal details" such as forces between parts of a system are completely subsumed by our treatment of the system as a single point. In other words, since we can only list forces applied *externally* to any object in its FBD, we cannot list or solve for the normal forces between the two blocks if we treat these as one system. So in fact, treating the two blocks as a system does not really save us any work, even though we have rather quickly obtained the acceleration. This is because in order to get the normal force between the blocks we must treat each block as a separate object, write out at least one of the two FBDs of each object, and starting now with the known acceleration continue to apply Newton's Second Law to get the unknown normal force.

Problem 2: Pushing Stacked Blocks with Friction

Note: This is an important problem, straight out of a previous year's First Hour Exam. Make sure you can do this problem.



Two blocks are placed together on a table as shown. Block A has a given mass m_A and Block B has a given mass m_B. There is **friction** acting on the surfaces between the two blocks. However, the surface of the table is **frictionless**. An instructor pushes horizontally on Block B with his finger with a constant given (known) applied force F_{app}. Assume also that **known** values of both the coefficient of static friction μ_s and the coefficient of kinetic friction μ_k are given parameters. Finally, here we observe that the given applied force F_{app} is small enough so that Block A **neither slips nor slides** relative to Block B. (In other words, Block A stays *stuck* to Block B).

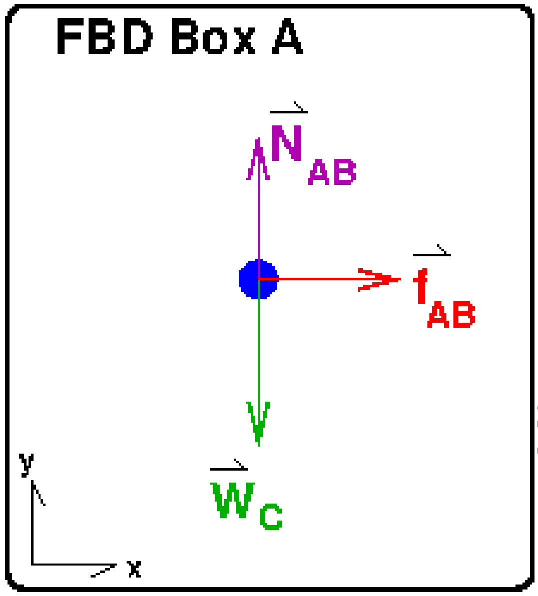
a) Draw two Free Body Diagrams (FBDs), one for each block, showing ***all*** vertical and horizontal forces on each. Make sure that your diagrams clearly indicate the nature (type) and direction of each force. Make sure that your forces are labeled with appropriate subscripts, as needed. (For example, $\vec{W}_A$ means the Weight Force on Block A. $\vec{N}_{AB}$ means the Normal Force on Block A due to Block B.)

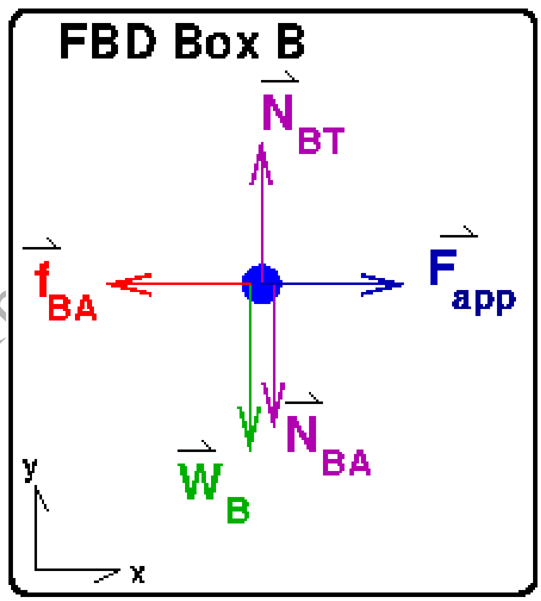
b) Calculate **all** of the forces on each of the two blocks. Also calculate the accelerations, a_A and a_B for each of the two blocks. Express your answers in terms of the given parameters. Show your work.

Important: please do not try to solve this problem by applying the concept of a "system" to the two blocks together. For this homework you are *obligated* to apply Newton's Second Law to each of the blocks separately and find the solution without using the concept of a 'system'.

SOLUTION TO PROBLEM 2:

Part (a):





To get full credit, all eight forces need to be listed with appropriate subscripts and the coordinate systems have to be included.

Part (b):

For this part we are told **no slipping, no sliding**. So we can conclude two things:

- The friction forces are **static** (by definition).

- The two blocks are **constrained** so that they move together. they blocks are "stuck together". This means that the position of Block A is **fixed relative** to the position of Block B. This means that the two blocks will **move as one unit**. So they will both have the same velocity. And they will both have the same (horizontal) acceleration: $a_{Ax} = a_{Bx} \equiv a_x$.

So with this **kinematic constraint** in mind, let's work **Newton's Second Law, One Body at a Time, One Component at Time:**

Newton's Second Law: Block A, vertical direction:

$$F_{Ay} = m_a a_y$$
$$N_{AB} - W_A = 0$$
$$N_{AB} = W_A$$

$$N_{AB} = W_A = m_a g \tag{1}$$

Newton's Second Law: Block B, vertical direction:

$$F_{By} = m_b a_y$$
$$N_{BT} - N_{BA} - W_B = 0$$

We apply **Newton's Third Law:**

$$N_{BT} - N_{AB} - W_B = 0$$
$$N_{BT} = N_{AB} + W_B$$
$$N_{BT} = m_a g + m_b g$$

$$N_{BT} = (m_a + m_b) g \tag{2}$$

Newton's Second Law: Block A, Horizontal direction:

$$F_{Ax} = m_a a_x$$

$$f_{AB} = m_a a_x \tag{3}$$

That's as far as we can get with Block A.

Newton's Second Law: Block B, Horizontal direction:

$$F_{Bx} = m_b a_x$$

$$F_{app} - f_{BA} = m_b a_x$$

Again we apply **Newton's Third Law:**

$$F_{app} - f_{AB} = m_b a_x \tag{4}$$

Now we have two equations, (3) and (4), and two unknowns: f_{AB} and a_x. Substituting (3) into (4) and solving for the acceleration:[1]

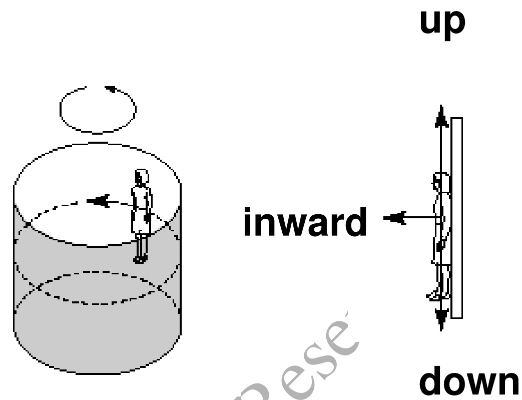
$$F_{app} - m_a a_x = m_b a_x$$
$$m_a a_x + m_b a_x = F_{app}$$
$$a_x(m_a + m_b) = F_{app}$$
$$\boxed{a_x = \frac{F_{app}}{m_a + m_b}}$$

Finally we plug this back in to get the friction force:

$$\boxed{f_{AB} = F_{app}\left(\frac{m_a}{m_a + m_b}\right)}$$

[1] An alternate solution to determine the acceleration: If we define both blocks together as a **system** with mass $M_{sys} = m_a + m_b$ then the only horizontal external force on this system is F_{app} and so the acceleration is given by that force divided by the mass of the system. Note however students should be able to solve this problem without defining a system.

Problem 3: Centripetal Acceleration with Friction



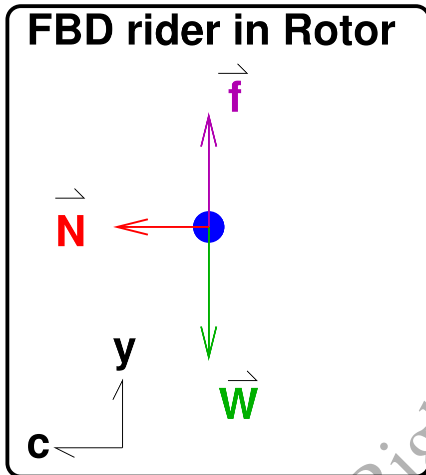
> "**The Rotor Ride:** *Perhaps the most feared ride at the amusement park is this small, seemingly non-intimidating attraction. It consists of a small barrel that spins in a circle about a vertical axis. Riders enter the ride and then stand with their backs against the inside wall of the barrel. As the barrel spins faster and faster, the centripetally inward force of the wall against the riders' backs becomes greater and greater. All of a sudden, the floor is dropped out from under the riders. It is the friction between the barrel wall and the riders that keep the riders from falling. The rotor ride is a great place to learn the thrill of centripetal acceleration."*

Part (a) – Consider the forces on a single rider as shown on the right-most figure above. Draw a careful and complete Free-Body-Diagram to indicate all of the forces on the rider. Be sure to indicate a proper coordinate system.

Part (b) – Assume that after the floor falls out, the rider is moving around inside the ride at a given constant speed V. Assume that the rider has a given mass M, and that the barrel of the rotor has a given radius R. Also assume that the coefficient of static friction between the rider and the wall is given as μ. Calculate the magnitude and direction of every force on the rider who is stuck to the wall after the floor falls away. Give your answer in terms of the given parameters. Explain you work.

Solution to Problem 3 (worth 20 points on a prior exam as follows):

Part (a): (5 points)



The correct FBD is provided above. Weight points down. Friction points up. Normal force inward (centripetal) horizontal.

Guidelines for exam graders:

- **Perfect FBD = 5 points.**
- **Missing coordinate system (either x-y or "c"-y okay). = 3 points.**
- **Missing and/or incorrectly directed force(s): 2 points or less.**

Solution to Problem 3 Continued

Part (b): (15 points)

We apply **Newton's Second Law** one component at a time:

Newton's Second Law: Vertical Component: The acceleration in the vertical component is **zero** (stuck to wall, not falling):

$$F_y = ma_y$$
$$f - W = 0$$

We know that $\boxed{W = mg}$ and so:

$$f - mg = 0$$
$$\boxed{f = mg}$$

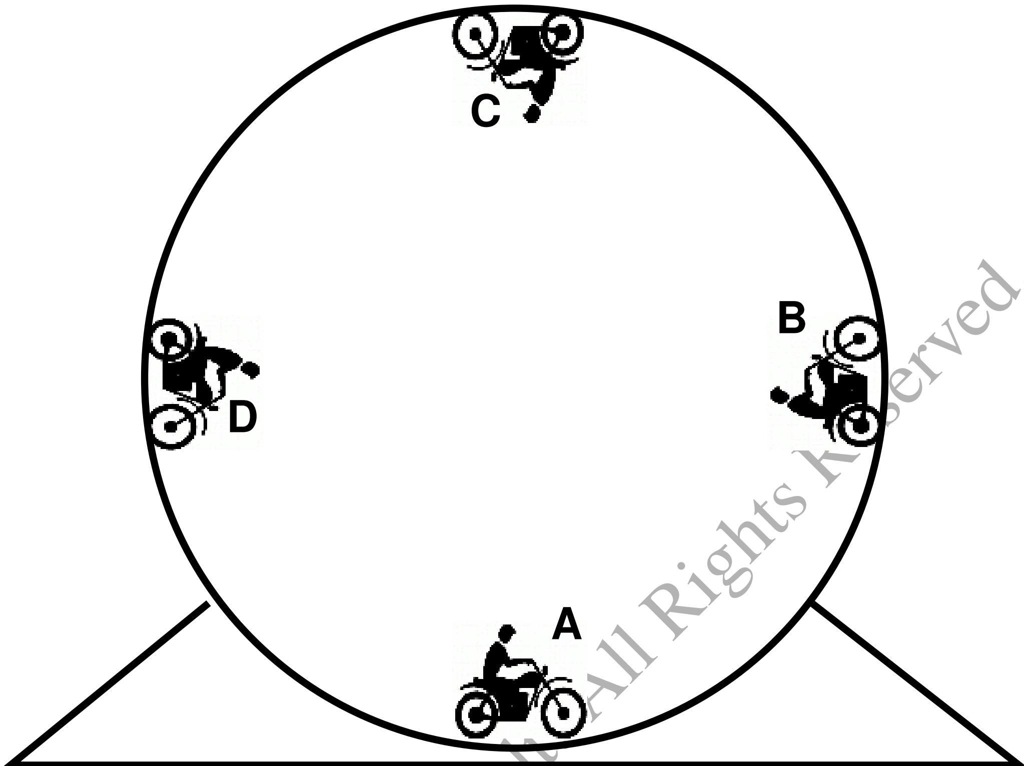
Newton's Second Law: Centripetal (Horizontal) Component: The acceleration in the horizontal component is **centripetal inward (left)**: $a_c = \frac{V^2}{R}$

$$F_c = ma_c$$
$$\boxed{N = \frac{mV^2}{R}}$$

Guidelines for graders:

- **Perfect Work all three forces calculated correctly invoking Newton's Second Law = 15 points.**
- **Incorrectly contending with centripetal acceleration: = 9 points or less**
- **Incorrectly assigning value of friction $f = \mu N$ or similar = 9 points or less**
- **Conceptually incorrect application of Newton's Second Law: 3 to 8 points.**
- **Answer based on incorrect or inappropriate physics ideas (e.g. Conservation Laws, torque, etc.): not more than 3 points.**

Problem 4:



A motorcyclist performs a somewhat nauseating trick by driving on a vertical circular track (so-called "loop-the-loop"). The position of the motorcyclist is show at four positions (A, B, C, D) corresponding to bottom, right, top and left points on the track respectively. The mass of the motorcyclist and his motorcycle together is given as m. The radius of the circular path is given as R.

Part (a) – Assume that the motorcyclist somehow maintains *constant speed* V. Draw a careful Free Body Diagram showing all of the forces on system that is the motorcyclist and his motorcycle together when he is in **Position C**. Calculate the magnitude and direction of each force.

Part (b) – Assume that the motorcyclist maintains *constant speed* V. Draw a careful Free Body Diagram showing all of the forces on system that is the motorcyclist and his motorcycle together when he is in **Position D**. Calculate the magnitude and direction of each force on your FBD.

Important hint: Treat the rider and the motorcycle together as a single "point" of mass m.

Another Important hint: For this problem, the requirement that the motorcycle maintains a constant speed does *not* mean that the rider is "coasting". Indeed, in order to maintain constant speed the rider will need to use use the "gas" and the "brake" in a particularly skillful way.

Another Important Hint: The track is *not* frictionless. Depending on the specifics of the motion, friction may or may not come into play at any given position on the track.

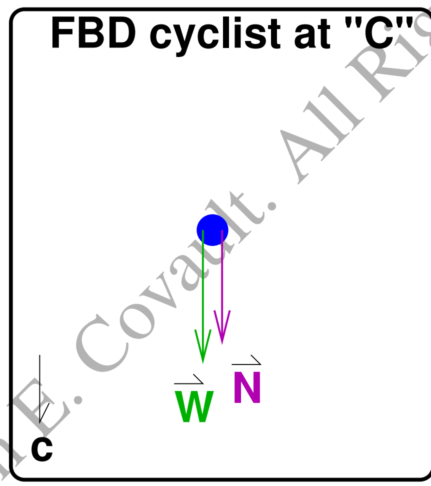
SOLUTION TO PROBLEM 4:

Since we are concerned with the values of forces and accelerations, this is a problem where we will apply **Newton's Law's of Motion**. We note that since there could be friction at any point along the track, we **fail to meet the Conditions** and we can apply neither Conservation of Mechanical Energy nor Conservation of Momentum to solve this problem.

We also note right away that since the cyclist is moving in a circle with constant speed that this problem has the **kinematics of Uniform Circular Motion** and therefore we know immediately that the acceleration is **centripetal** (toward the center of the circle) with a known value of $a_c = \frac{V^2}{R}$ and this remains true for every position on the track.

Part (a):

At point "C" the cyclist is in contact with the track. Since the surface of the track can only **push**, and not pull, the Normal force on the motorcycle due to the track points down. Here is the **Free Body Diagram** for the motorcycle+rider:



There is the issue of whether or not we expect a force of *friction* to apply to the motorcycle at point "C". This requires some care. We resolve this question by considering the fact that the **speed of the motorcycle is constant** and therefore it is neither speeding up nor slowing down. Friction is a force that is (by definition) applied *parallel* to the surface. At the top of the track, this would correspond to either horizontal to the *left* or horizontal to the *right*. But if there were a non-zero force of friction in *either* direction, left or right, at Point C, then the speed of the motorcycle would be changing. This would correspond to a non-zero tangential acceleration. Since the speed is constant, the tangential acceleration must be zero and therefore there must be zero net force in the tangential (horizontal) direction. Therefore, we know that there is $\boxed{\text{zero friction at point C.}}$ This means any FBD for the motorcycle at point "C" with friction of any kind is wrong.

We apply **Newton's Second Law:** in the *centripetal* (downward) coordinate (as indicated by the little c in the FBD):

$$F_c = ma_c$$

$$N + W = m\frac{v^2}{R}$$

$$N = m\frac{V^2}{R} - W$$

$$N = m\frac{V^2}{R} - mg$$

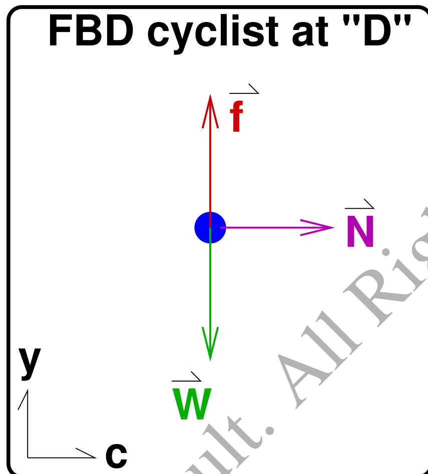
$$\boxed{N = m\left(\frac{V^2}{R} - g\right)}$$

Note that this equation implies a minimum value of V. If the speed is too slow, no positive value of the Normal force N will give the required centripetal acceleration: "The Normal force goes to zero" means the motorcycle loses contact with the track. This is a bad thing, especially if you are riding the motorcycle.

(Problem Solution continues next page...)

Part (b):

We now apply the same prescription at Point “D”. Here, the Weight still points down, and the Normal force is centripetal, but this is now toward the center of the circle (horizontal, to the right). We again need to consider friction. If there were zero friction, then the only vertical force would be Weight and the net force on the motorcycle in the vertical direction would be *downward* so that the speed of the motorcycle would be increasing. However, since the speed is known to be constant, there must be another force acting in opposition to the weight. The only such force possible from our Force Menu is friction. Here, friction must act in the negative tangential direction (upward). This is what the FBD looks like:



Important: Note that we have labeled the horizontal component as “c” to remind ourselves that this is now the direction of the centripetal acceleration. We also need a label for the vertical component, here I choose the standard Cartesian coordinate “y”.

First we apply **Newton’s Second Law** in the vertical coordinate to get the friction at point “D”. This is easy:

$$F_y = ma_y$$
$$f - W = ma_y$$
$$f - W = 0$$
$$f = W$$
$$\boxed{f = mg}$$

(Problem solution continues next page....

We continue with **Newton's Second Law** in the *centripetal* coordinate to get the Normal force on the cycle at point "D":

$$F_c = ma_c$$

$$N = ma_c$$

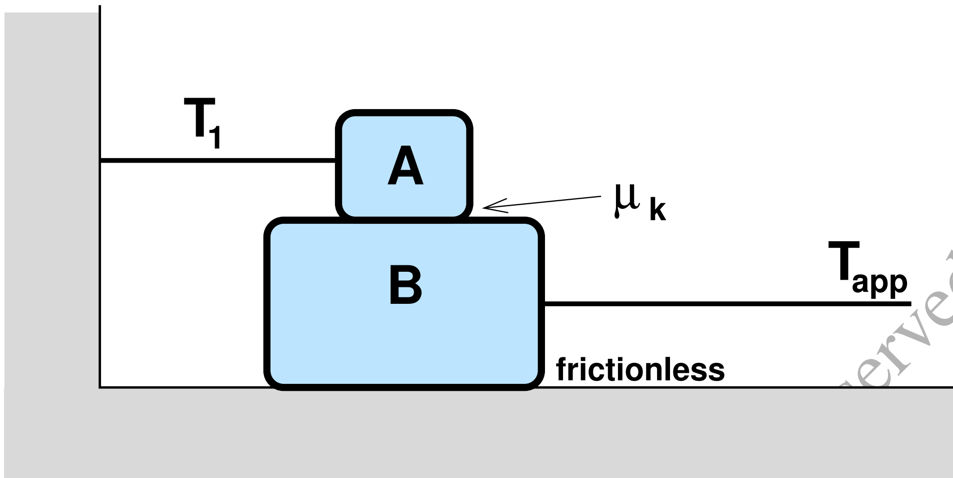
$$N = m\left(\frac{v^2}{R}\right)$$

$$\boxed{N = \frac{mV^2}{R}}$$

Note in particular that in dealing with the friction, we have not invoked any kind of 'coefficient of friction' or anything like this. The equations that look like $f = \mu N$ do not apply at all in this problem. You have not been told that there is sliding (kinetic) friction here. In fact, if the motorcycle tires are "rolling without slipping" then this corresponds to *static* friction. But the *kind* of friction is not really relevant to the solution of the problem. The fact that we are told that the cyclist maintains constant speed is a fact that, together with Newton's Second Law, absolutely determines the exact value of the friction force at Point "D".

If you think about it, you will realize that the requirement that the motorcyclist maintain a constant speed requires some tricky controls. We want zero friction at the top and the bottom of the track. But we need friction to counteract gravity at the sides of the track. The motorcyclist controls the friction by changing the way the wheels apply force to the track. Specifically, the cyclist must be applying the breaks on the way down the left side and he must be hitting the gas on the way up the right side. This is a maneuver that requires considerable skill. Don't try this at home.

Problem 5: Pushing Friction and Tension Together:



Block A with a given mass m_A is positioned on top of Block B with a given mass m_b. The coefficient of kinetic (sliding) friction between Block A and Block B is given as μ_k. Block B sits on a frictionless surface. Block A is tied to the wall with an ideal string which prevents Block A from moving to the right. A given constant horizontal tension force T_{app} is applied to Block B as shown, with the result that Block B slides to the right.

Part (a) Carefully draw a neat "Free Body Diagram" (FBD) for each of the two blocks. Be sure to indicate and properly label all forces that are applied to each block.

Part (b) If you have drawn your two FBDs correctly, there will be two "Third Law Forces Pairs." Which four forces correspond to these two pairs? Explain how you know this.

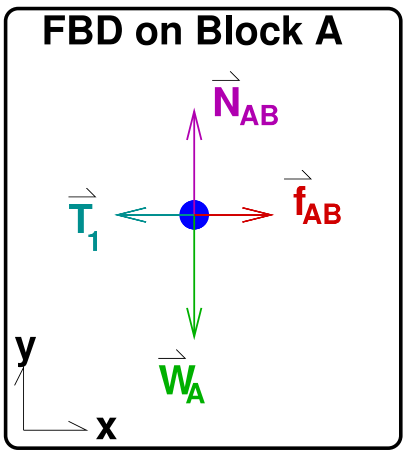
Part (c) Determine T_1, the tension in the rope that is attached to Block A in terms of the given parameters. Explain your work. Hint: the rope does more that simply provide a force of tension on Block A. The rope also imposes a ***kinematic constraint*** on the acceleration of Block A.

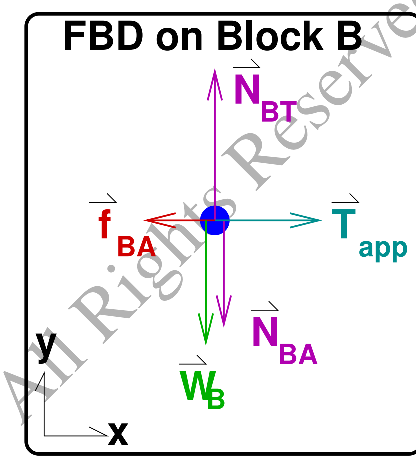
Part (d) Determine a_x, the acceleration of Block B in terms of the given parameters. Explain your work.

SOLUTION TO PROBLEM 5:

Part (a):

Here are the two **Free Body Diagrams** for the two blocks below. There are a total of **four forces on Block A**. This includes a Weight force on Block A, a Normal force on block A due to Block B, a tension force to the right due to the string, and a force of sliding friction which points to the right. There are a total of **five forces on Block B**: which includes Weight, Normal on B due to the frictionless table, Normal on B due to Block A, the applied Tension force, and the sliding friction force on Block B which points to the left:





Part (b) :

Newton's Third Law says that for every force on Body A due to Body B, there is an equal an oppositely directed force on Body B due to Body A. We see that forces between the two blocks include **a Normal force** and **sliding friction**. We can see by the index labeling that $\boxed{\text{the friction forces } \vec{f}_{AB} \text{ and } \vec{f}_{BA} \text{ represent a Third-Law Pair.}}$ Likewise $\boxed{\text{the Normal forces } \vec{N}_{AB} \text{ and } \vec{N}_{BA} \text{ represent another Third-Law Pair.}}$

Part (c):

To solve this problem, we must apply **Newton's Second Law** for Block A using the forces listed in the FBD. We start with the **vertical coordinate:**

$$F_{A_y} = m_A a_{A_y}$$

We put in the forces for the left side:

$$N_{AB} - W_A = m_A a_{A_y}$$

and then apply the fact that the vertical acceleration must be zero:

$$N_{AB} - W_A = 0$$

Therefore:

$$N_{AB} = W_A$$

$$N_{AB} = m_A g$$

Next, we apply **Newton's Second Law** for Block A in the **horizontal coordinate:**

$$F_{A_x} = m_A a_{A_x}$$
$$f_{AB} - T_1 = m_A a_{A_x}$$

We know that Block A is held in place, so the acceleration is zero:

$$f_{AB} - T_1 = 0$$

We know the expression for sliding friction:

$$\mu_k N_{AB} - T_1 = 0$$

We have the Normal Force from the vertical coordinate work:

$$\mu_k m_A g - T_1 = 0$$

We easily solve for the unknown force magnitude T_1

$$\boxed{T_1 = \mu_k m_A g}$$

Part (d) :

Again we apply **Newton's Second Law** to the motion of Block B, this time working only the horizontal coordinate:

$$F_{B_x} = m_B a_x$$
$$T_{app} - f_{BA} = m_B a_x$$

We know $f_{BA} = f_{AB}$ from **Newton's Third Law:**

$$T_{app} - f_{AB} = m_B a_x$$

From the previous calculation we know the sliding friction already:

$$T_{app} - \mu_k m_A g = m_B a_x$$

Solving for the one unknown value a_x we get:

$$\boxed{a_x = \frac{T_{app} - \mu_k m_A g}{m_B}}$$