PHYS 121: Homework #02 and Reading Assignment for Week #03

28 January 2024

This Homework is due Monday, February 5 at 11 PM and must be submitted online as a single legible PDF file via Canvas.

Physics 121: Spring 2024: Week #03 Reading assignment:

- **PHYS 121 Course Documents on Canvas as follows:**
  - **REQUIRED:** Read **P121 Course Documents #04:** Cycle 1 Review Sheet, Part 1, if you have not already done so. Important stuff here that you will need for this homework.
  - **REQUIRED:** Read **P121 Course Documents #06:** Cycle 1 Review Sheet, Part 2.

    Note: The "Review Sheets" correspond to what we consider the essential information for the course. What we tell students is this: Before you study anything else, make sure you are completely comfortable with everything on the Review Sheets.
  - **REQUIRED:** Read **P121 Homework #01 Solutions**. Note: Homework Solutions are Required Reading for PHYS 121.

    Note: The solutions correspond to 43 pages of typeset text and figures. We recapitulate each problem, we **highlight the main physics concepts** and then we provide detailed solutions with commentary. In our view the Homework Solutions are the most important "textbook" for the entire course. Even if you feel you "understood" the homework problems and/or earned a good grade on the homework, we strongly encourage all students to read and review the solutions.

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Reading for Week #03 continue...

- $\boxed{\textbf{REQUIRED:}}$ *Physics 121 Online Class Notes* ***Cycle 1, Chapters 6 through 8 and 12***, posted on the Course Website, as follows:
  - **Read Chapter 6:** A first glance at vectors. Technically, the mathematics of vectors is material that you should already know. However, students often need a refresher. We will not dig deeply into breaking forces into vector until we get to Cycle 2.
  - **Read Chapter 7:** An introduction to Friction. Note that any rule that you may have once learned that “friction always acts in opposition to the motion” is ***not correct***. Note that the only practical difference between static and kinetic friction is the fact that kinetic friction is generally “known” (determined by the coefficient of friction) whilst static friction is generally “unknown” and can only be determined by applying Newton’s Laws.
  - **Read Chapter 8:** An introduction to ropes, tension and pulleys. Tension is very analogous to the Normal force. Tension is a **pull** and the Normal force is a **push**. Usually it is completely “unknown” and can only be determined by applying Newton’s Laws. Note that an ideal pulley only changes the direction of the tension.
  - **Finally slightly “out of order” Read Chapter 12:** We start thinking about motion that is not just 1-D in a straight line but curved around a circular path. Skim pages 12-5 to 12-9 for now: we will tackle centripetal vs. tangential acceleration in Cycle 2.

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Physics 121: Spring 2024: Homework #02

This Homework is due via Canvas at: 11 PM Sharp, Monday, February 5, 2024

Important note: This homework will be graded on a scale of 0 to 15 points. **Not all problems will be graded.**

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.

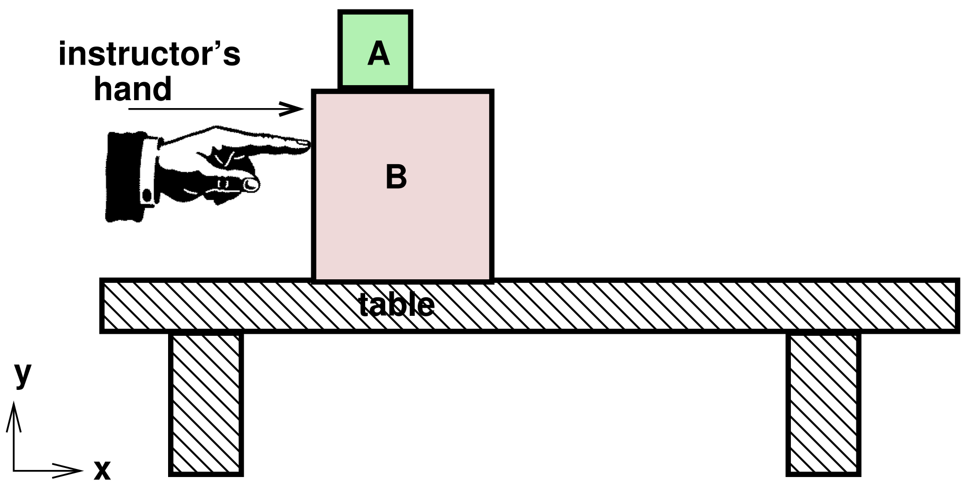
- **Part (c):** What is the magnitude of the Normal force exerted on Block 1 due to Block 2? Explain your work.

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!

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.



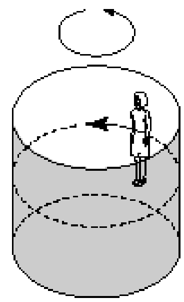
Two blocks are placed together on a table as shown. Block A has a given mass m_A and Block B has a given mass m_B. There is **friction** acting on the surfaces between the two blocks. However, the surface of the table is **frictionless**. An instructor pushes horizontally on Block B with his finger with 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).

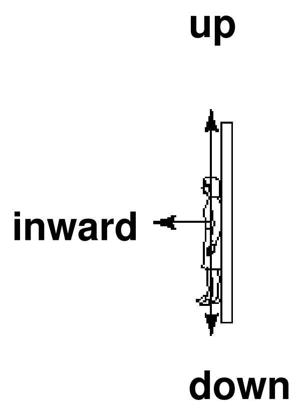
a) Draw two Free Body Diagrams (FBDs), one for each block, showing ***all*** vertical and horizontal forces on each. Make sure that your diagrams clearly indicate the nature (type) and direction of each force. Make sure that your forces are labeled with appropriate subscripts, as needed. (For example,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

Problem 3: Centripetal Acceleration with Friction



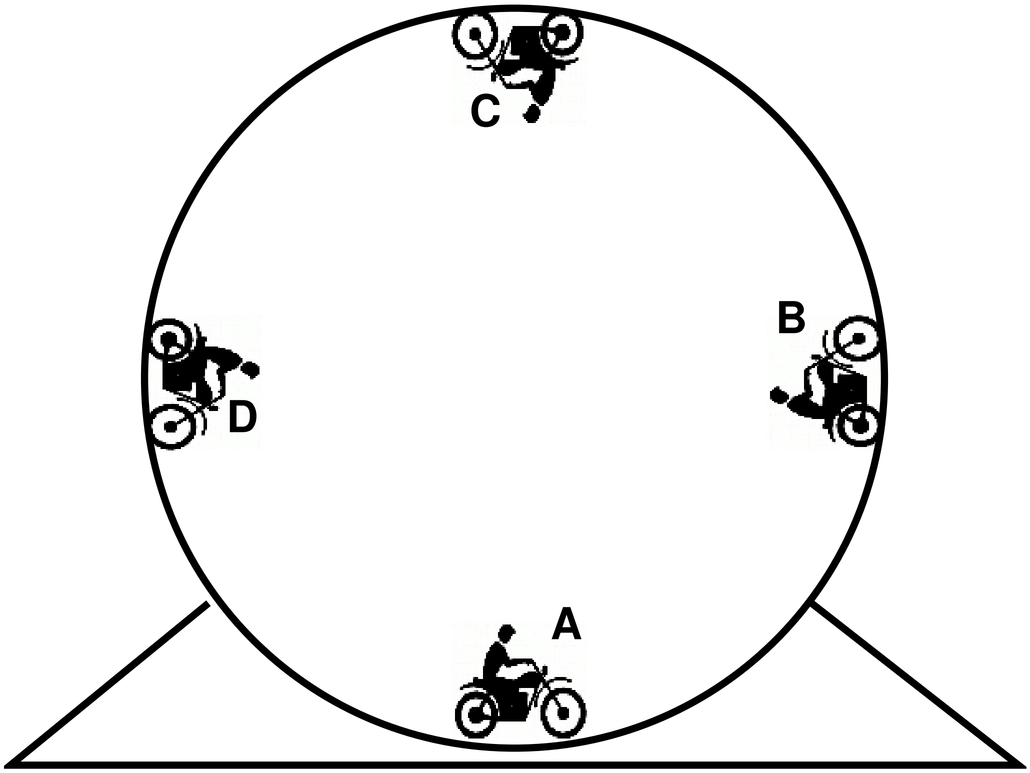


> "**The Rotor Ride:** *Perhaps the most feared ride at the amusement park is this small, seemingly non-intimidating attraction. It consists of a small barrel that spins in a circle about a vertical axis. Riders enter the ride and then stand with their backs against the inside wall of the barrel. As 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.

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.

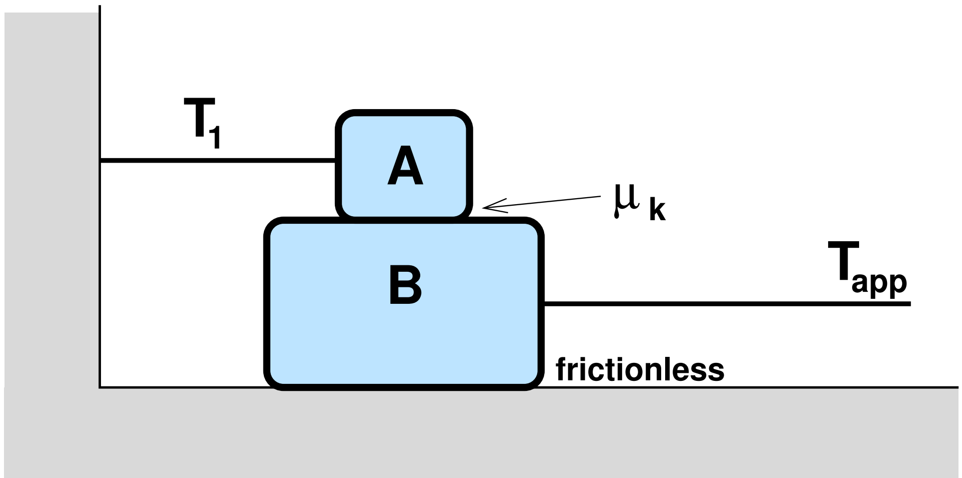
Part (b) – Assume that the motorcyclist maintains *constant speed* V. Draw a careful Free Body Diagram showing all of the forces on system that is the motorcyclist and his motorcycle together when he is in **Position D**. Calculate the magnitude and direction of each force on your FBD.

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.

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.