**Free-Body Diagram (FBD) 101 For AP Physics Exams**

There are 3 types of FBD Questions that students will be asked to do on the AP Physics exams: The super dot, the super dot with a grid, and the rolling object on an incline.

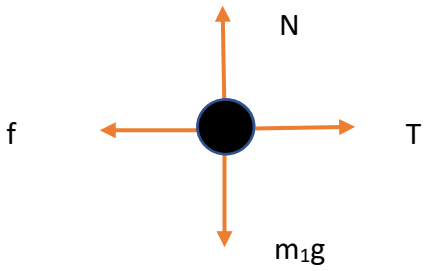
1. **The "Super dot"**- Students will be asked to draw and label the forces acting on an object (or multiple objects) in a variety of situations. There are some rules to follow that are specifically laid out in the question prompt.
   a. **Draw and Label the forces (Not components) that are acting on the object**
   Standard labels for common forces would be: Gravitational force= Fg, $F_G$, W, mg; Normal Force= N, $F_N$; Tension= T, $F_T$, $F_{string}$, Friction= f, $F_f$, $F_k$, $F_{FR}$, $f_s$, $f_k$

   **Note:** Labels of G, g and "gravity" are NOT allowed for the gravitational force.
   **Note:** If there are 2 distinct objects, students should distinguish the gravitational force. For example, $W_1$ vs $W_2$ or $m_1g$ vs Mg
   b. **Each force MUST be represented by a distinct arrow, starting on, and pointing away from the dot.**
   Students cannot draw one force vector on top of another one. Each force vector much be separate. The "super dot" allows the space for that. Force vector must also start on and point away from the dot means the vector cannot point toward the dot.

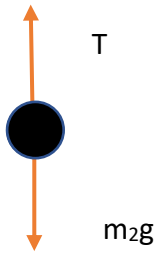
**Example:** A block of mass $m_1$ is sitting on a table with a coefficient of friction μ. A block of mass $m_2$ is hanging over the side of the table. It is connected by a string of negligible mass that is over a pulley with negligible mass to the block of mass $m_1$.

a) On the dots below, which represent the blocks, draw and label the forces (not components) that act on each block. Each force must be represented by a distinct arrow starting on, and pointing away from the dot.

Block 1

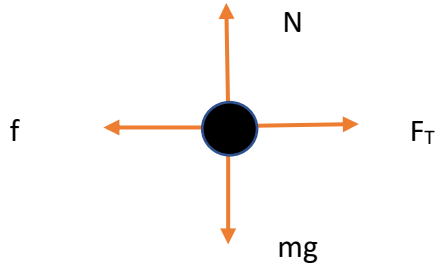



Block 2

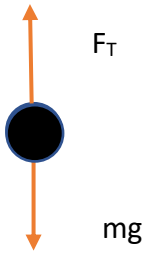



Full credit for labels and force vectors.

Block 1

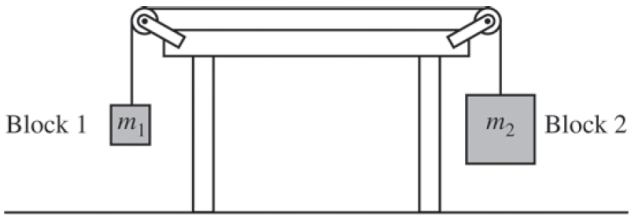



Block 2




Depending on the rubric, this may lose a point because the gravitational force is labeled as being the same for both blocks.

2. **The "super dot" with a grid**- This FBD has the same requirements as the "super dot", with 1 major addition. The relative lengths of the arrows should show the relative magnitudes of the forces. So, if Tension is the same on 2 separate objects, the arrow length representing the tension forces must be the same. If an object is accelerating in a specific direction, the force vector in the accelerating direction must be larger than the force vector drawn in the opposite direction.

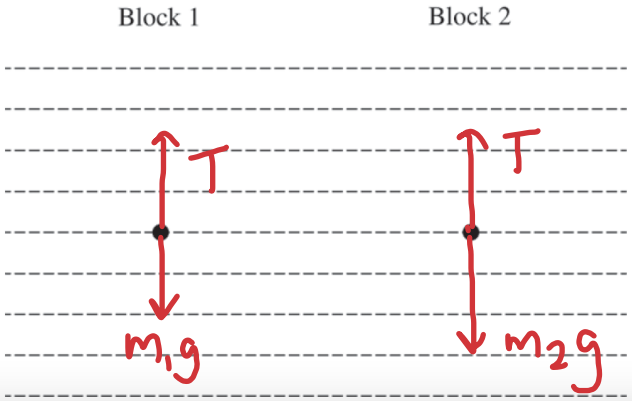



Note: Figure not drawn to scale.

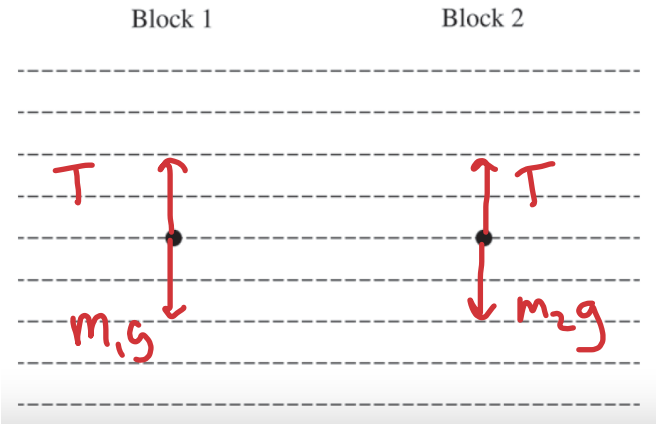
1. (7 points, suggested time 13 minutes)

Two blocks are connected by a string of negligible mass that passes over massless pulleys that turn with negligible friction, as shown in the figure above. The mass $m_2$ of block 2 is greater than the mass $m_1$ of block 1. The blocks are released from rest.

(a) The dots below represent the two blocks. Draw free-body diagrams showing and labeling the forces (not components) exerted on each block. Draw the relative lengths of all vectors to reflect the relative magnitudes of all the forces.

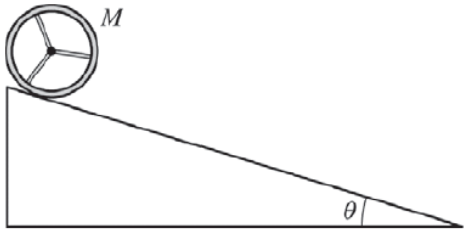



Full credit.
* $m_1g$ is smaller than $m_2g$
* T's are same length
* $m_2g$ larger than its T
* T on block 1 larger than $m_1g$




Would lose most points
* $m_1g$ and $m_2g$ are same length
* Both blocks show a=0 since vertical force vectors are equal
* Tensions are equal (as they should be)

3. **Rolling Object on an Incline**- The FBD for a rotating object will ask the students to start their force vectors at the point at which the force is exerted. That means gravitational force arrow must start at the center of the object and point straight down. The Normal force arrow must start at the surface of the incline and point up, perpendicular to the incline and friction will be an arrow up the incline starting where the rolling object makes contact with the incline.

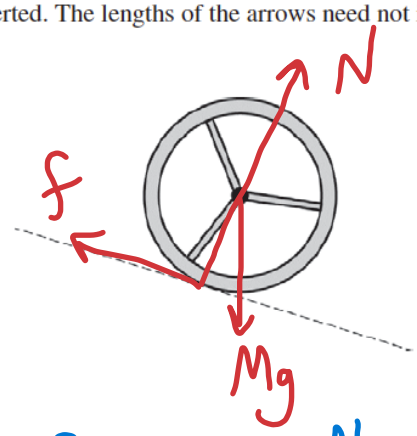



1. (7 points, suggested time 13 minutes)

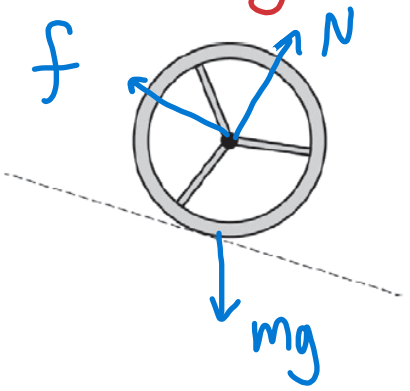
A wooden wheel of mass $M$, consisting of a rim with spokes, rolls down a ramp that makes an angle $\theta$ with the horizontal, as shown above. The ramp exerts a force of static friction on the wheel so that the wheel rolls without slipping.

(a)

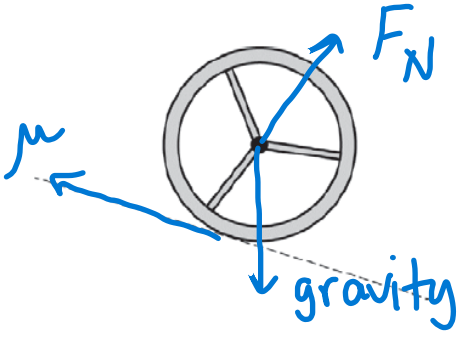
i. On the diagram below, draw and label the forces (not components) that act on the wheel as it rolls down the ramp, which is indicated by the dashed line. To clearly indicate at which point on the wheel each force is exerted, draw each force as a distinct arrow starting on, and pointing away from, the point at which the force is exerted. The lengths of the arrows need not indicate the relative magnitudes of the forces.




Full credit
* All forces properly labeled and start at correct point of application




* Forces are labeled correctly, but none are starting at the correct spot. (likely 0 pts)




* Correct placement of friction and force of gravity, but unacceptable labels are used. Normal force has ok label, but does not start at surface