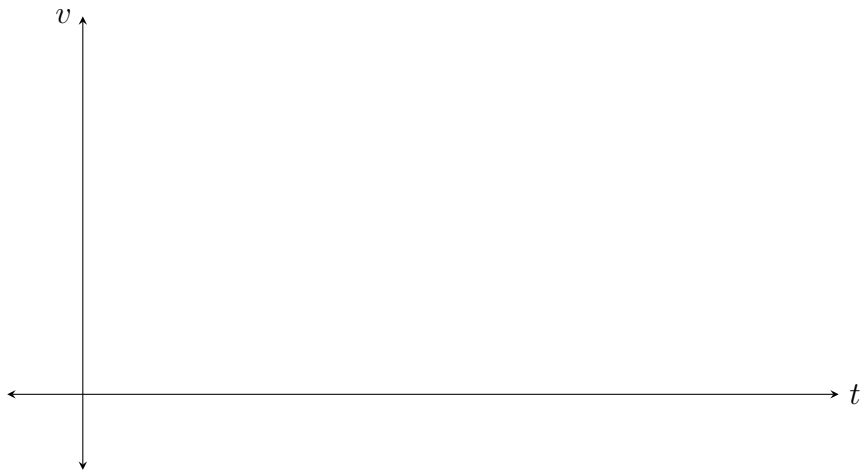
# I. Applying Newton's laws to a system with friction

Suppose that a block slides down a fixed, inclined plane with $\theta = 30\,\text{deg}$. You have analyzed the material of the block and the plane previously and have found that they have a coefficient of kinetic friction of $\mu_k = 0.3$.

(a) In the space below, draw a free-body diagram for the block just after it has been released from rest. You should ensure that your diagram is accurate in the direction that the forces point, but it need not have accurate force magnitudes. All important angles should be labeled.

(b) In the space below, sketch a qualitatively correct graph of velocity vs. time ($v$ vs. $t$) for the block. You should assume that the block is released from rest at $t = 0$ and the velocity is positive if it is moving down the ramp.




(c) On the same set of axes above, show the $v$ vs. $t$ graph that *would have been* correct if there was *no* friction. Make sure that both graphs are consistent with each other and be prepared to defend your rationale to another group/the instructor.

⇒ **PAUSE and check with an instructor or another group.**



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Now let's see if we can go from qualitative predictions to quantitative predictions.

(d) How will you orient your coordinate system for this problem? Show how it will be oriented on your free-body diagram on the previous page and defend your choice in the space below. [Hint: You should choose your x and y directions so that the *fewest* number of forces need to be broken down into coordinates.]

(e) Break down your forces into components along each direction of your coordinate system of choice. Relate the net force to the acceleration in each direction and simplify your result.

_____-component _____-component

(f) Simplify the equations above and solve for the acceleration of the block $a$.

(g) Ensure that the previous result matches the $v$ vs. $t$ graph that you drew in part (b). Resolve any inconsistencies.

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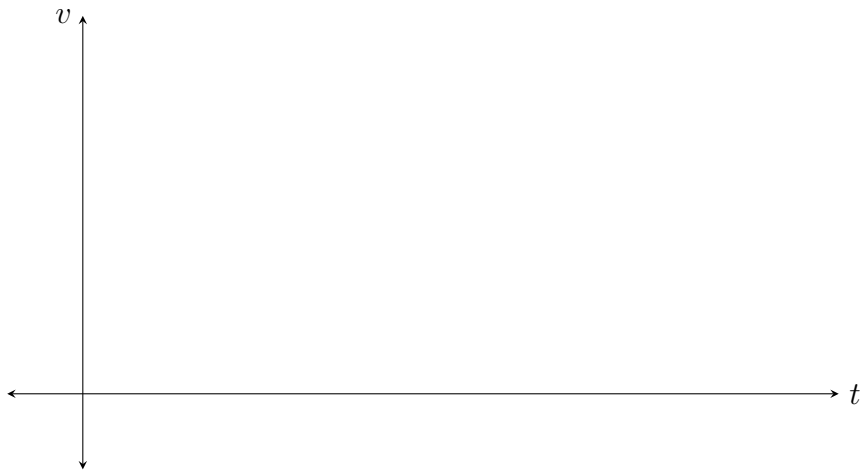
# II. Applying Newton's laws to a system with friction

Suppose that a block is at the bottom of a fixed, inclined plane with $\theta = 30\,\text{deg}$. You have analyzed the material of the block and the plane previously and have found that they have a coefficient of kinetic friction of $\mu_k = 0.3$. The block is initially given a quick shove up the ramp.

(a) In the space below, draw a free-body diagram for the block just after it has been shoved up the ramp.

(b) In the space below, sketch a qualitatively correct graph of velocity vs. time ($v$ vs. $t$) for the block. You should assume that the block is moving at speed $v_0 \neq 0$ after the shove has finished at $t = 0$ and the velocity is positive if it is moving up the ramp.




(c) On the same set of axes above, show the $v$ vs. $t$ graph that *would have been* correct if there was *no* friction. Make sure that both graphs are consistent with each other and be prepared to defend your rationale to another group/the instructor.

⇒ **PAUSE and check with an instructor or another group.**



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Now let's see if we can go from qualitative predictions to quantitative predictions.

(d) Can you re-use the coordinate system that you had from part I? Show how it will be oriented on your free-body diagram on the previous page and defend your choice in the space below.

(e) Break down your forces into components along each direction of your coordinate system of choice. Relate the net force to the acceleration in each direction and simplify your result.

_____-component _____-component

(f) Simplify the equations above and solve for the acceleration of the block $a$.

(g) Ensure that the previous result matches the $v$ vs. $t$ graph that you drew in part (b). Resolve any inconsistencies.

⇒ **PAUSE and check with an instructor or another group.**



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