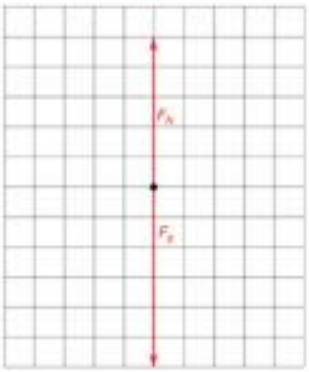
NAME _____ DATE _____

Scenario

A 300 kg box rests on a platform attached to a forklift shown. Starting from rest at time $t = 0$ seconds, the box is lowered with a downward acceleration of 1.5 m/s².

Using Representations

PART A: The dot below right represents the box. Draw a free-body diagram showing and labeling the forces (not components) exerted on the block. Draw the relative lengths of all vectors to reflect the relative magnitudes of all forces. Each force must be represented by a distinct arrow starting on and pointing away from the dot.



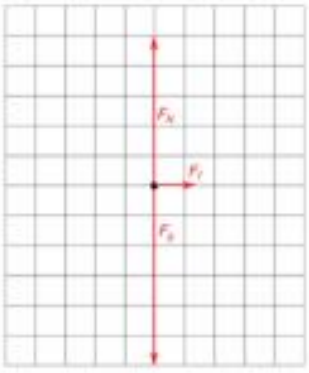
PART B: In a brief sentence, support the magnitude of the normal force in comparison to the gravitational force on the box.

Because the box is accelerating downward, the net force must also be downward, meaning that the magnitude of the normal force must be less than the gravitational force: $F_N < F_g$

Argumentation

PART C: Blake derives an equation for the height of the box as a function of time, makes a mistake, and comes up with $y = 9.8t$. Without deriving the correct equation, how can you tell that this equation is not plausible— in other words, why does it not make physical sense? Briefly explain your reasoning.

The box is accelerating, so it will have a changing speed, which means that position cannot depend linearly on time. Also the inclusion of 9.8 is dubious since the acceleration here is not due to gravity.



PART D: At time $t = 0$ seconds, the forklift also begins to move forward with an acceleration of 2 m/s² while lowering the box as described above. The box does not slip or tip over while the forklift is accelerating forward. The dot at right represents the box. Draw a free-body diagram showing and labeling the forces (not components) exerted on the block. Draw the relative lengths of all vectors to reflect the relative magnitudes of all the forces. Each force must be represented by a distinct arrow starting on and pointing away from the dot.

PART E. Explain in a brief sentence why the force of friction points in the direction you sketched in Part D.

Because if the box was at rest, and the platform exerted no friction, the box would appear to "slide backward" as the platform moved forward. Because there is friction, that friction force keeps the box stationary relative to the platform, while the platform moves forward. Therefore the friction force is forward.

Checklist:

- ✓ I answered the question directly.
- I stated a law of physics that is always true.
- I connected the law or laws of physics to the specific circumstances of the situation.
- I used physics vocabulary (force, mass, acceleration, velocity, constant, changing).

Quantitative Analysis

PART F. When the box is only being accelerated forward, a_{max} has one value. (a_{max} is the maximum acceleration the forklift can have before the box begins to slide.) When the box is both accelerating forward and down, a_{max} is less. Explain in a clear, coherent paragraph-length response why this is true.

Because the friction force depends on the normal force, when the forklift is only accelerating forward, the maximum acceleration that it can have without the box sliding is related to the coefficient of friction and the normal force (which in this case is equal to the weight of the box). When the box is also being accelerated downward, the normal force is less, so there is a smaller maximum static friction force, and hence, a smaller maximum acceleration the forklift can supply without causing the box to slip.