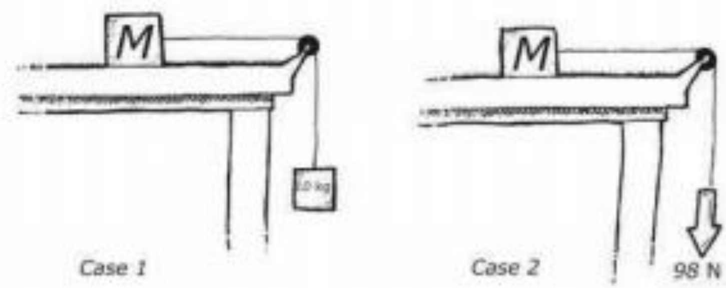
NAME ______________________________ DATE ______________



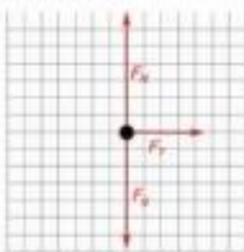
Scenario

In both cases shown above, a block of mass M is set on a rough table. The block is connected to a string that passes over an ideal pulley. In Case 1, the free end of the string is connected to a hanging object of mass $m = 10\ \text{kg}$. In Case 2, the hanging object is removed and a person grabs the free end of the string and pulls with a constant force equal to $98\ \text{N}$, the weight of the hanging object in Case 1. In both cases, the block is released from rest the same distance from the right edge of the table.

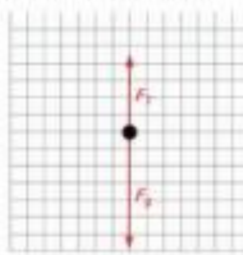
Using Representations

PART A: The dots below represent each object in Case 1. Draw the forces acting on those objects after the system is released. Use the grids to draw longer arrows to represent stronger forces. Assume that $m < M$. Recall that the system is accelerating.

Case 1: Block M



Case 1: Hanging object m



Argumentation

PART B: Angela and Dominique are observing this demonstration and note that the block accelerates in both cases. However, the block reaches the right edge of the table in less time in Case 2 even though the force on the string in this case is the same as the weight of the hanging object in Case 1.

i. This occurs because there is a different amount of tension in the two cases. Explain why the block reaches the end in less time in Case 2 in terms of the different tension force in each case.

In Case 2, the acceleration is larger, so it reaches the edge faster than in Case 1. This happens because the force of tension, in Case 2, is now 98 N, whereas in Case 1, the tension is less than 98 N. Analyzing the hanging object in Case 1, we can see that if the tension were equal to 98 N, the hanging object would not accelerate downward—so for the hanging object to accelerate downward, the force of tension, in Case 1, must be less than 98 N.

ii. This can also be explained by considering systems. Let the system in Case 1 consist of both the hanging object and the block on the table. Let the system in Case 2 consist only of the block on the table. Explain how Newton's second law, when applied to these systems, predicts that the block in Case 2 reaches the end of the table in less time.

The system in Case 1 consists of two objects M and m. The net external force that causes the acceleration $F_g - F_f$ has to accelerate both objects. In Case 2, the net external force $F_g - F_f$ only has to accelerate one block, M, so the acceleration must be larger making the time to travel the same distance smaller.