AP Physics 1 - Dynamics Test

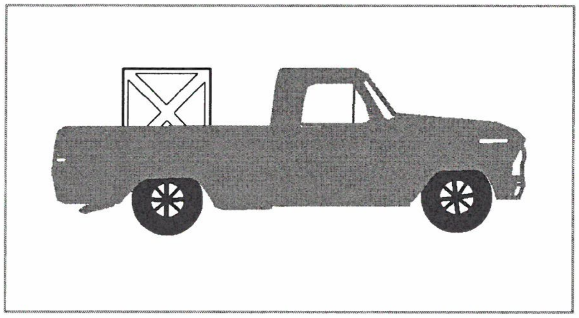
Key

MULTIPLE CHOICE SECTION

Directions: Mark only one answer for each question. Use $g = 10\ m/s^2$ for simplicity.

v constant ∴ a=0

1.

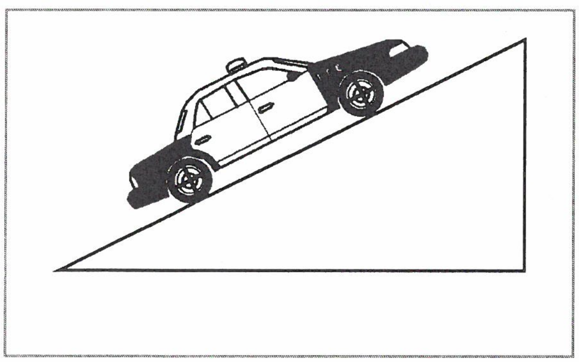


A truck traveling to the right with constant speed carries a box in its rear. The driver suddenly applies the brakes and the truck slows to a stop. The instant that the brakes are applied, the box slides toward the front of the truck. What force is responsible for the box sliding toward the front of the truck?

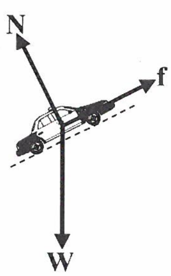
Box slide forward, Because there is not enough friction to prevent it from sliding

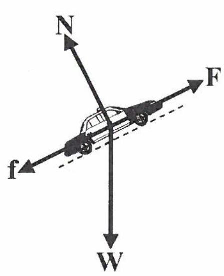
a. Weight
b. Inertia - is Not a force!
c. Friction Force
d. There is no force that caused the box to slide forward.

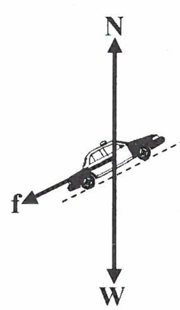
2.

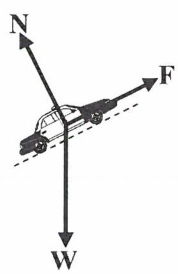


A car with good tires travels up a hill with constant speed. Let **W** represent the weight, **N** represent the normal force, and **f** represent the static friction force acting on the car. Any other external force on the car is labeled **F**. Which of the following diagrams correctly shows the forces acting on the car as it travels up the hill?

a.


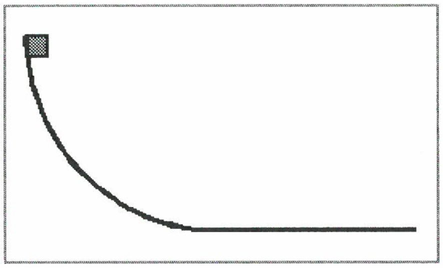
b.


c.


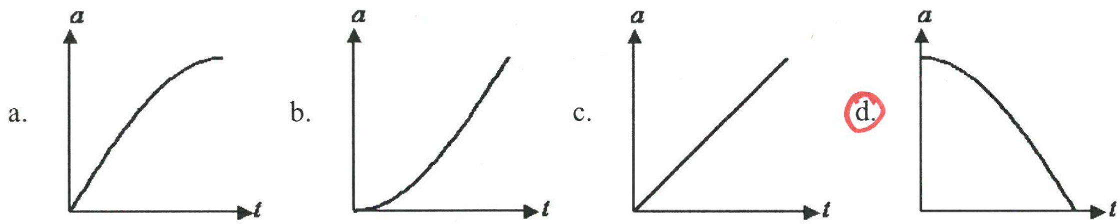
d.


ANS: A
The weight force points directly downward and the normal force points perpendicular to the surface. The force that causes the car to go up the hill is the frictional force between the tires and the road (sometimes called "traction"). There is no other force (other than weight, normal, and friction) acting on the car.

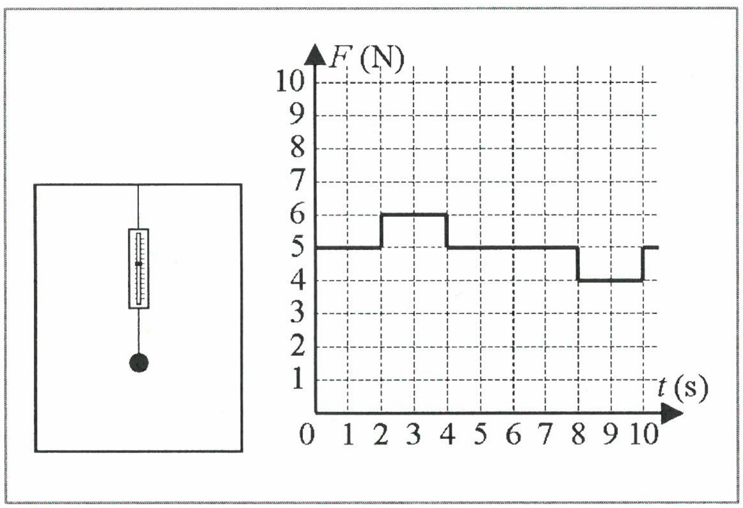
SKIP 3.



A block slides from rest down a frictionless quarter-circular incline as shown. Which of the following graphs represents the block's tangential acceleration as a function of time while the block is on the quarter-circle?



4.



A known mass hangs from a force sensor inside of an elevator. As the elevator moves from the bottom floor to the roof-level of a building, the upward force acting on the mass is recorded as a function of time in the graph shown. Which of the following questions could NOT be answered by the data in the graph and the known mass?

a. What is the acceleration of the elevator as it leaves the ground floor?
b. What is the maximum speed attained by the elevator?
c. What is the approximate height of the building?
d. All of these questions could be answered by these data.

PTS: 1

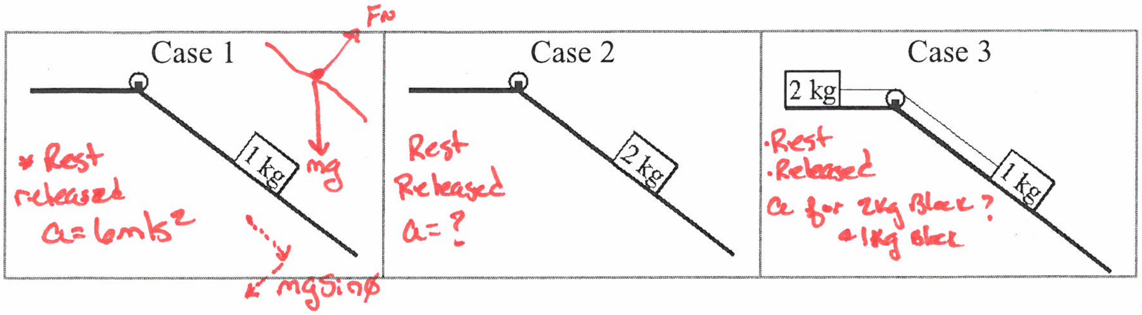
4. ANS: D

The acceleration of the can be found by using the equation $F_{net} = ma$ and recognizing that the forces on the ball are the spring force up (called F in the table) and the weight (mg) down. Therefore, knowing F from the graph and using $F - mg = ma$, we can get the acceleration of the elevator anytime. We can also get the speed of the elevator if we know the acceleration because we can use $v = at$ and the acceleration and time from the graph. We can also use kinematics equations like $x = \frac{1}{2}at^2$ to turn acceleration and time into distance (like the height of the building).

Key

#5 The acceleration depends on the incline angle and NOT on the mass, so both masses in case 1 and case 2 should have the same acceleration.

Questions 5-6: The diagrams below show three situations in which one or more blocks are set on a frictionless track. The frictionless track has an inclined section and a horizontal section. A pulley wheel separates these two sections. In Case 1, a 1 kg block is set at rest on the inclined section. Upon release, the 1 kg block has an acceleration of 6 m/s².



5. In Case 2, a 2 kg block is set on the inclined section and released from rest. What acceleration will the 2 kg block have as it slides down the incline?

$\Sigma F_y = -mg\sin\theta = -ma$

$-mg\sin\theta = -ma$

$a = g\sin\theta$

∴ mass not an affect

a. $2\ m/s^2$ b. $3\ m/s^2$ c. $4\ m/s^2$ d. $6\ m/s^2$

6. In Case 3, the 2 kg block is connected to the 1 kg block by a string. The 2 kg block rests on the horizontal section, the 1 kg block is held fixed on the inclined section, and the string passes over the ideal pulley. What acceleration will the system of blocks have the instant that the 1 kg block is released?

$F = ma$ $a = 6m/s$ $m = 1kg$

$F = (6)(1)$

$F = 6N$

Still only F on system is $a = g\sin\theta$

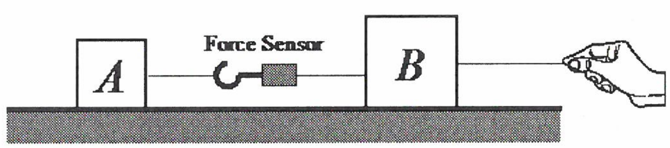
∴ $F = ma$ $m = 3kg$ $F = 6N$

$a = \frac{F}{m}$

$a = \frac{6N}{3kg} = 2m/s^2$

a. $2\ m/s^2$ b. $3\ m/s^2$ c. $4\ m/s^2$ d. $6\ m/s^2$

7.



Block *A* is attached to Block *B*, which is attached to a rope that is being pulled with constant force. There is a very light force sensor between the blocks that is oriented to measure the constant tension force on Block *A* in this case. The student wishes to verify Newton's Third Law. Which of the following should the student also do in order to gather appropriate data to verify Newton's Third Law?

a. Change the orientation of the force sensor.
b. Apply the same force on Block *A* in the opposite direction.
c. Switch Blocks *A* and *B* in the experimental setup.
d. Replace the rope with a spring.

PTS: 1

7. ANS: A

The force sensor is measuring the forward force on block *A*, which (according to Newton's Third Law) should be the same as the backward force on block *B*. To get the backward force on block *B*, just switch the direction of the force sensor.

8. ANS: D

The car's engine cannot exert a force on the car because the engine is part of the car system. A part of a system cannot exert a force on the system as a whole. The only thing that can speed up a car is an object not part of the car system (normally the road which exerts a friction or traction force on the car). Key

8. A student attempts to explain how a car accelerates forward by saying that "the car's engine exerts a forward force on the car." This statement is

a. True, because a car without a working engine cannot accelerate forward.
b. True, because the engine exerts a force on the car's wheels, making them turn.
c. False, because the engine is not in direct contant with the wheels of the car.
d. False, because a net force on the car must come from an object or system that is outside of the car.

9.

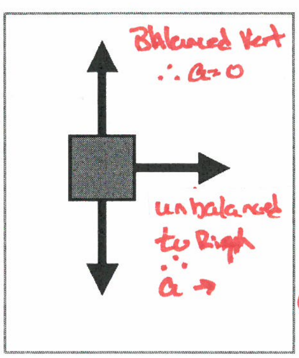
Case 1 Case 2

A block of mass m_1 is initially at rest on top of a block of mass m_2, also at rest. There is noticeable friction between the blocks, but not between m_2 and the table. In case 1, a force F is applied to m_1, causing both blocks to accelerate and also slip against each other. In case 2, the same force F is instead applied to mass m_2, which again causes both blocks to accelerate and slip against each other. In which case does the acceleration of the m_1-m_2 center of mass have greater magnitude?

a. Case 1
b. Case 2
c. Both the same
d. Depends on which mass is greater

Directions: Mark two answers for each question.

10.



Three forces of equal magnitude act on the box shown. One force is upward, one downward, and one rightward. Which of the following statements must be true based on this information? Select two answers.

B) - Could have Constant Velocity up or down

(A) The box must have a rightward component of velocity. · Could Be moving Right left & slowing Down
(B) The box has no vertical component of velocity.
(C) The acceleration of the box is directed to the right.
(D) The velocity of the box is changing with time.

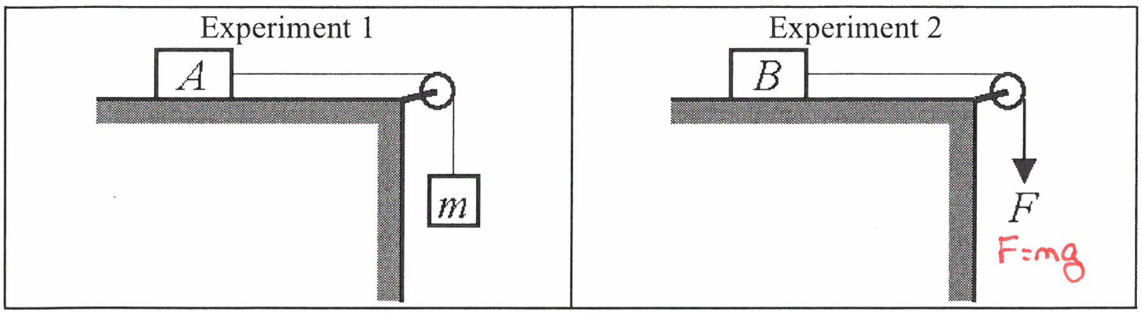
9. ANS: C

The center-of-mass accelerates only due to the action of forces external to the m_1-m_2 system. Any force of one block pushing each other or friction between the blocks is internal. External forces on the m_1-m_2 system include the weight of both blocks, the normal force of the table pushing up on m_2, the F force (which acts on the system no matter which block F is applied directly to), and the table's friction on m_2. The weights are canceled by the normal force of the table, so the only unbalanced external forces are F and the table's friction (which is the same because both cases have the same total block weight). Since both cases have the same forward force F (doesn't matter which block it is applied to) and the same backward friction force from the table, both cases must have the same center-of-mass acceleration.

Key

FREE RESPONSE SECTION

11. (7 Points)
A student performs two experiments using identical boxes A and B. Both boxes are placed on horizontal tables with identical frictional properties and each table is fitted with an ideal pulley at one end. A rope is connected to the box in each experiment and the rope passes over the pulley. In Experiment 1, the free end of the rope is connected to a mass m. In Experiment 2, the free end of the rope is pulled with a force F such that $F = mg$ (the force F is the same strength as the weight of the mass m). Once each system is released, blocks A and B both experience an acceleration.

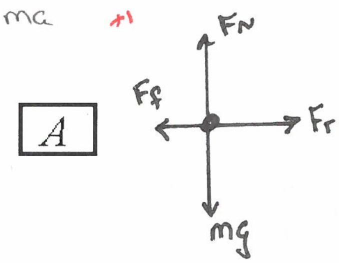


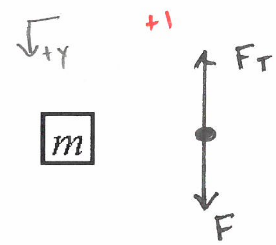
(a) On the diagrams below that represent block A and the mass m, draw and label forces acting on the blocks once the systems are released from rest and are accelerating. Recall that there is friction between both blocks and the table.

$\Sigma F_x = F_T - F_f = ma$ +1

$\Sigma F_y = -F_T + F = m$ +1

2pts





(b) Which block, upon being released from rest, experiences a greater magnitude of acceleration?

1pt

___ Block A ✓ Block B ___ Both have the same acceleration.

In a well-organized paragraph-length response that may include equations and/or figures, explain your reasoning.

ANSWER RUBRIC #1

(3) The student recognizes that the net external forces on Experiment 1 are the weight of m and friction, and that the net external forces on Experiment 2 are the force F and friction.
(4) The student recognizes that both systems in both experiments have the same net force.
(5) The student recognizes that Experiment 1 is a system with greater total mass.
(6) The student argues (from Newton's Second Law) that a greater mass for Experiment 1 and equal net forces results in less acceleration in Experiment 1.
(7) The student's paragraph presents a logical argument that (however wrong) can be followed and understood by the reader and does not contradict itself.

Continued

Key

12. (12 Points) See next sheet

A student is interested in high-performance racing. The student, while learning about high-performance racing, comes across a research document that claims that rubber materials experience a kinetic friction with concrete such that the frictional force is directly proportional to sliding speed.

(a) Would this claim be valid for materials such as wood, glass, and metal? If so, why? If not, why not?

See next Sheet

The student wishes to experimentally test this claim. The student obtains a piece of tire rubber shaped like a rectangular prism and a long slab of concrete. The student has access to other materials commonly found in a high-school physics laboratory.

(b) i. What additional materials would the student need in order to perform the experiment?

ii. Outline a procedure that the student could follow to collect data that would be needed to test the claim. Be sure to explain how the materials listed above are used to make measurements. Include a labeled diagram.

(c) Explain how the student would analyze the data in order to test the claim.

Key

12) 12 Pts

$F_K = \mu_K F_N$

+1. a) No, the claim is not valid, there is no dependence on speed in $F_K = \mu_K F_N$

12. ANS:

(a) 1 Point

(1) No, the claim would not be valid because $F_f = \mu F_N$ does not have any dependence on speed.

(b) 5 Points

(2) For all materials listed being used in the lab procedure to either measure the force applied to the rubber piece or the speed of the rubber piece. Equipment to measure the mass of the cube could also be included if the procedure explains that the cube's mass is to be measured. Any other extraneous equipment listed or equipment not used in the procedure prevents the student from earning this point.

(3) The procedure is such that the student can measure the frictional force on the block. (Example: Pull the rubber block across the concrete with a spring scale so that the block slides at constant speed.)

(4) The procedure is such that the student can measure speed of the block. (Example: Pull the rubber block across the concrete next to a meterstick. Use a stopwatch to measure how long it takes for the block to pass the meterstick and travel one meter.)

(5) Each piece of equipment (other than timing equipment) is clearly labeled in the diagram.

(6) The procedure indicates that multiple trials must be taken where the speed of the block is varied.

(c) 2 Points

(7) In either part (b) or part (c), the student clearly explains how the direct measurements of distance and time are used to find the speed of the block.

(8) The student indicates a valid data analysis technique such as making a graph.

(d) 4 Points

(9) The graph is properly labeled with axes quantities, units, and two scales that allow the data points to take up more than half of the graph space horizontally and vertically.

(10) Six points are correctly plotted on the graph and a best-fit line or curve is drawn.

(11) The student states that the data DO NOT support the claim of direct proportionality.

(12) The student explains WHY the data do not support the claim, such as the fact that the graph is a curve (or line that does not pass through the origin) or the fact that each pair of force and speed do not divide to the same ratio all the way across the table.

Key

#12

(d) The data taken by the student are shown below on the data table.

Sliding Speed (m/s)	5.0	10.0	15.0	20.0	25.0	30.0
Frictional Force (N)	1.74	2.76	3.61	4.37	5.07	5.73

i. Plot the data on the axes below. Draw a best-fit line or curve.

Scale ✓

Sliding

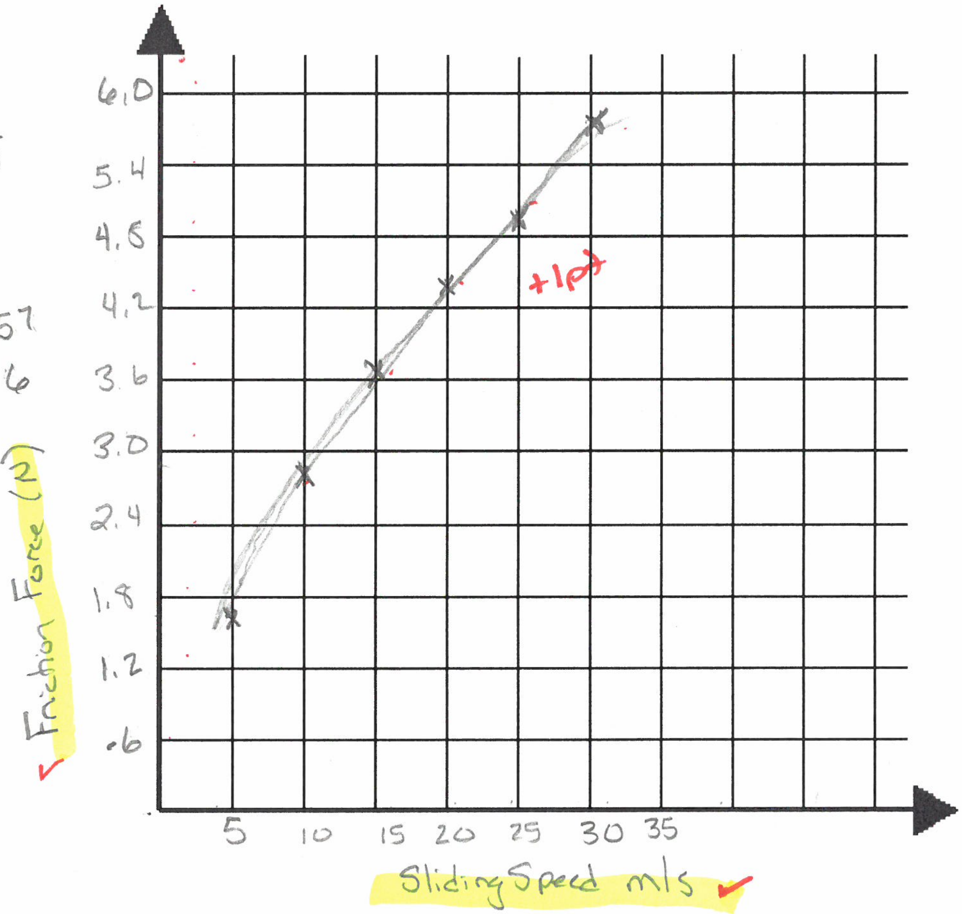
$\frac{30-5}{10} = \frac{25}{10} = 2.5 \approx 5$

Friction

$\frac{5.73-0}{10} = \frac{5.73}{10} = .57$

$\approx .6$

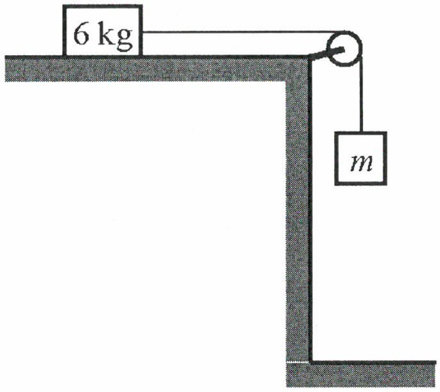
1+pt

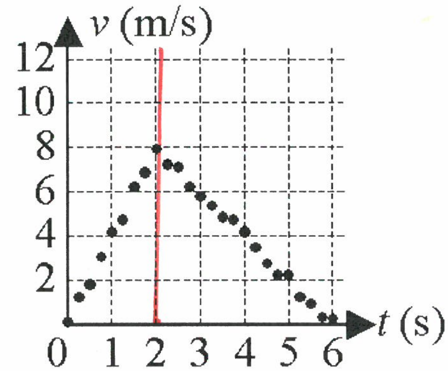


ii. Do the data support the claim that the frictional force is directly proportional to sliding speed? Why or why not?

+2 Not direct (see Answers + Examples)

13. (7 Points)





t=2

A 6 kg block is set on a rough table and connected to a hanging mass by a string that passes over an ideal pulley. The system is released from rest at time $t = 0$, and the block speeds up as the mass falls. Once the mass strikes the floor, the block comes to rest again. A student uses measurement apparatus to collect data of the block's velocity as a function of time. The data are shown in the graph above right.

Calculate each of the following. For each part, explain how you use the graph and given information along with physical principles to make your calculation.

(a) The strength of the friction force acting on the block as it slides

2pts

F_N, F_f, F_T, mg

• After 2 secs only Force Acting is F_f

$-F_f = ma$

• Slope of V vs t is a, After 2 sec (needs to A due to F_f) $\frac{Rise}{Run}$ $\frac{0-8}{6-2} = \frac{-8}{4} = -2 m/s^2$

+1 $a = -2 m/s^2$

+1 $-F_f = (6kg)(-2 m/s^2)$

$F_f = 12 N$

(b) The strength of the tension force of the string after the system is released but before the hanging mass strikes the floor

3pts

$F = ma$ F_T is force Before hitting Floor   a is from t=0 to t=2 $\frac{Rise}{Run} = \frac{8-0}{2-0} = 4 m/s^2$ +1

$\Sigma F_x = F_T - F_f = ma$ +1

$F_T = ma + F_f$

$= (6kg)(4 m/s^2) + 12 N$

$F_T = 36 N$ +1

(c) The amount of hanging mass

2pts

F_T, mg, $+\downarrow$

+1 $-F_T + mg = ma$

$mg - ma = F_T$

$m(g-a) = F_T$

$m = \frac{F_T}{g-a}$

$F_T = 36 N$

$g = 10 m/s^2$

$a = 4 m/s^2$ (Before hit)

$m = \frac{36N}{(10-4)}$

$= \frac{36N}{6 m/s^2}$

+1

$\boxed{m = 6 kg}$