AP Physics - Unit 2 - Dynamics

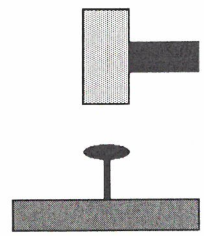
Key 1/7

Pre-Assessment Questions

The "action" and "reaction" of Newton's Third Law represent two forces that act at the same time. Since they act at the same time, they cannot be "cause" and "effect". In fact, "action" and "reaction" are "cause and cause"; the two effects are the resulting motions or changes in motion of the two objects acting on each other. In the boxes below, fill in the blanks to correctly represent the "action" cause-and-effect and "reaction" cause-and-effect that take place in the situation described. The first one has been done for you.

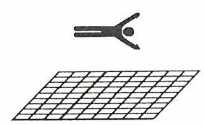
P1.	Cause	Effect
"Action"	The hammer pushes down on the nail.	The nail moves downward into the board.
"Reaction"	The nail pushes up on the hammer.	The hammer bounces off of the nail.

Situation: A hammer strikes a nail.



P2.	Cause	Effect
"Action"	The person Pushes ("pushes" or "pulls") Down (direction) on the net.	The net bows downward.
"Reaction"	The net Pushes ("pushes" or "pulls") UP (direction) on the person.	The person person stops (or slows down) falling.

Situation: A falling person lands in a net.



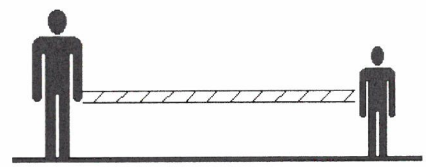
P3.	Cause	Effect
"Action"	The Airplane (object) Pushes ("pushes" or "pulls") down (direction) on the Air (object).	The air flows downward.
"Reaction"	The Air (object) Pushes ("pushes" or "pulls") up (direction) on the Plane (object).	The airplane stays at the same height.

Situation: An airplane flies without falling or rising because it interacts with the air.

Key 2/7

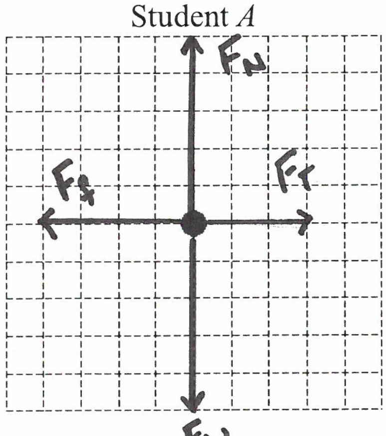
P4.	Cause	Effect	Situation: A gun fires a bullet.
"Action"	The gun pushes forward the Bullet	The Bullet Accelerates forward	
"Reaction"	The Bullet pushes Backward on the gun	The gun recoils (Jumps) Backwards	

P5. Student *A* is much heavier and stronger than Student *B*. Both students engage in a tug-of-war match, and Student *A* wins. Student *C*, observing this, says "Student *A* won because he pulled on the rope with more force." This is incorrect.

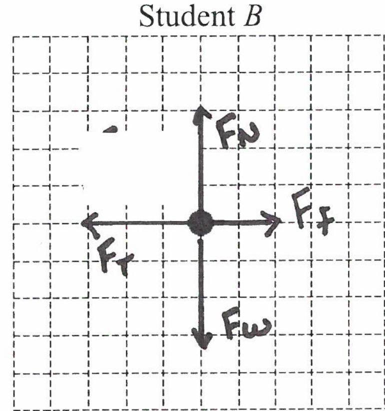


(a) Draw free-body diagrams showing the weight, normal, friction, and tension forces on each student. Use the grid so that longer arrows can represent stronger forces.

Student *A*



Student *B*



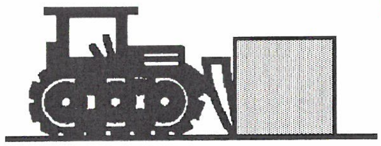
$F_T = F_T$

(b) Correct the student's statement about who pulled harder on the rope, and use your FBDs to explain what actually causes Student *A* to win the tug-of-war. (Hint: *B* could win the tug-of-war of *A* were standing on a wet tile floor.)

- The Rope has the same tension on Both Ends, no matter How Strong student A is or weak student B is.
- what wins the tug-of-war is Student A has more friction Acting to left than Student B has.
- Looking At forces on A, there is more leftward Friction than Rightward Tension, so A accelerates to the Left
- If A had slippery shoes, He would Be much less likely to win

KEY 3/7

Multiple-Choice Questions



M1. A heavy tractor force F_T to push a lighter box. Under which conditions will F_B, the force with which the box pushes on the tractor, be equal in magnitude to F_T?

(A) The tractor and box must be at rest.
(B) The tractor and box must be moving with constant velocity.
(C) The tractor and box must be either at rest or moving with constant velocity.
(D) These two forces are always equal in magnitude under all conditions.

Forces are "tractor on Box" & "Box on Tractor" Action Reaction Pair ∴ $F_A = F_B$ Equal Mag & opposite direction

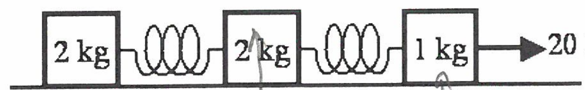
M2. Which of the following best explains what a person does in order to jump vertically into the air?

(A) The person uses her legs to push herself up off of the ground with a force equal to her weight.
(B) The person pushes down on the floor with a force equal to her weight, causing the floor to exert an upward force on the person equal to her weight.
(C) The person uses her legs to push herself up off of the ground with a force greater than her weight.
(D) The person pushes down on the floor with a force greater than her weight, causing the floor to exert an upward force on the person greater than her weight.

An object CANNOT exert a force on itself. They Push down on Floor w/ Force > than F_W

SKIP

Questions 3–4: Three blocks set at rest on a frictionless surface are connected by identical springs. The rightmost block is acted upon by a constant 20 N force, as shown below, starting at time $t = 0$. The blocks no longer oscillate after 10 seconds.



M3. Which of the following will be true after 10 seconds have elapsed?

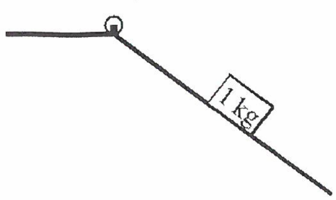
(A) The right spring will be stretched twice as far as the left spring.
(B) The left spring will be stretched twice as far as the right spring.
(C) The right spring will store twice as much potential energy as the left spring.
(D) The left spring will store twice as much potential energy as the right spring.

M4. What is the speed of the center of mass of the system at $t = 2$ seconds, while the blocks are still oscillating? SKIP

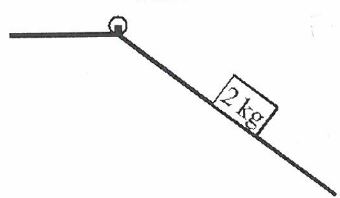
(A) 2 m/s
(B) 8 m/s
(C) 10 m/s
(D) 20 m/s

Questions 5-6: The diagrams below show three cases in which one or more blocks are set on a frictionless track. The frictionless track has straight and inclined sections separated by a pulley wheel. In Case 1, a 1 kg block is set at rest on the inclined section and has an acceleration of 6 m/s^2 upon being released.

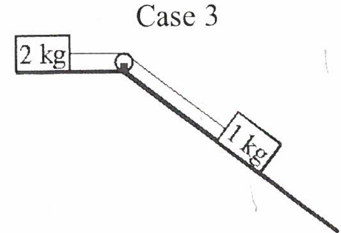
Case 1



Case 2



Case 3



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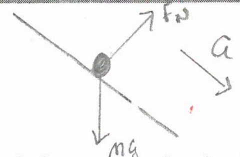
m = 2 kg



M5. 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?

(A) 1 m/s^2 (B) 2 m/s^2 (C) 3 m/s^2 (D) 6 m/s^2

The acceleration, on frictionless Incline depends only on gravity & Angle Not mass

M6. 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?

(A) 1 m/s^2 (B) 2 m/s^2 (C) 3 m/s^2 (D) 6 m/s^2

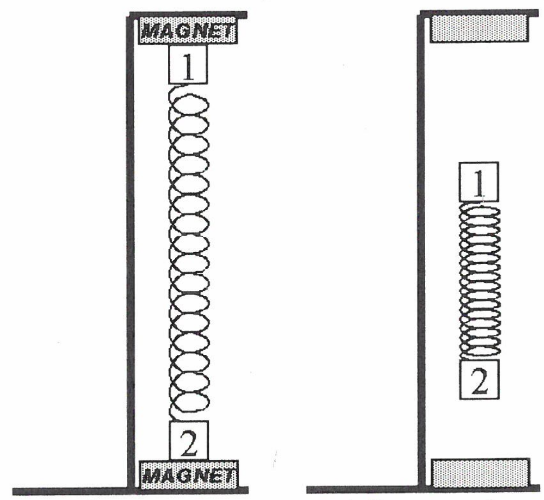
1 kg Alone
$F = ma$
$F = (1\text{ kg})(6\text{ m/s}^2)$
$F = 6\text{ N}$

2 kg + 1 kg
$F = ma$
$a = \frac{F}{m}$
$a = \frac{6\text{ N}}{3\text{ kg}} = 2\text{ m/s}^2$

Free-Response Questions

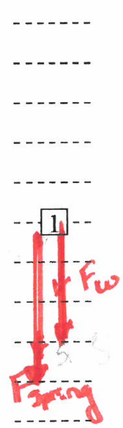
F1

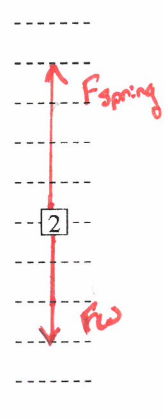
F1. A system consists of two identical steel cubes 1 and 2. The cubes are connected by a strong spring. The diagram shows each cube stuck to an electromagnet and held so that the spring is stretched several times its natural length. At time $t = 0$, both electromagnets are turned off, and immediately both cubes lose contact with their respective magnets.



Before $t = 0$ After $t = 0$

(a) The boxes below represent the two cubes immediately after both cubes lose contact with their respective magnets. On each box, draw and label the forces (NOT components) acting on each cube at this instant. Use the dashed lines to draw arrows whose lengths reflect the relative magnitudes of the forces.



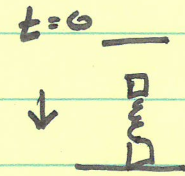


(b) After time $t = 0$, is the system in free-fall? If so, what is accelerating at 9.8 m/s^2? If not, why not?

Yes the system is in free fall. The center of mass of system accelerates at 9.8 m/s^2

(c) Suppose instead that at time $t = 0$ the magnet for cube 1 turned off but not the magnet for cube 2. Would the downward acceleration of cube 1 be greater, lesser, or the same as the acceleration of cube 1 in the original case? Justify your answer.

FRQ 1



c)
(1pt) The downward acceleration would be greater

(1pt) The 2 downward forces of weight & the spring are what causes cube 1's acceleration

Key
(1pt) The spring force doesn't decrease as rapidly in the new case because the spring length doesn't decrease as quickley (since cube 2 doesn't move)

FRQ 2 - Design experiment demo 3rd law * meterstick
12pts
* String * Carts * Different masses * Stopwatch

(a) 4 points

(1) The student's setup involves two objects connected by either a string or a spring so that the two objects can pull on each other.

(2) The student's setup has no friction.

(3) The student's setup has the ability to measure the mass of both carts and the acceleration for both carts as they pull on each other.

(4) All of the checked pieces of equipment are used, and the diagram shown is simple, labeled, and makes sense in the context of the procedure.

Example Response: Take two of the carts and put different masses in them. Connect them with the elastic cord and stretch the carts apart. Place two motion detectors to "watch" each cart's motion as the carts are released and accelerate together. Use the balance to get the mass of each cart and its contents.

Example Response: Take a cart and put some masses in it. Connect the cart to another mass by the string and make the mass hang over the edge of the table. Release the mass a known distance above the floor, as measured by the meterstick. Time how long it takes for the mass to reach the floor. Use the balance to get the mass of the cart and the hanging object.

FRQ 2 Cont:

(b) 3 points

(5) The student explains how acceleration is to be measured. The student cannot merely say "measure the acceleration", as none of the pieces of equipment actually directly measure acceleration.

(6) The student explains how the force is to be calculated. The student can merely say that mass times acceleration yields force.

(7) The students state that the forces must be compared to determine if they are equal (as required by Newton's Third Law).

Example Response: The motion detectors can create velocity vs. time graphs. Take the slope of each velocity vs. time graph to get each cart's acceleration. Then multiply each cart's acceleration by its mass to get the force, which should be the same.

Example Response: The fall distance of the hanging mass x and the fall time t can be plugged into $x=\frac{1}{2}at^2$ to solve for the acceleration of both cart and hanger. The mass of the cart times its acceleration is the tension in the string. Subtract the hanger's mg and the hanger's ma to get the tension on the hanger. Both tensions should be the same.

(c) 1 point

(8) Yes, and the student explains how the setup can be used to measure each cart's initial and final velocity. If the student stated NO, then the student must explain where an external force acts in the setup to receive this point.

In the "carts coming together" examples above, the motion sensors can be used to measure initial and final speed, and so the change in momentum of each cart could be measured. In the "cart and hanging object" examples, there is an external force of weight on the hanging object, so conservation of momentum cannot be demonstrated by this setup.

(d) 4 points

(9) $F_{A\to B} = -F_{B\to A}$ (the student starts with some statement of Newton's Third Law)

(10) $m_B a_B = -m_A a_A$ (the student substitutes in ma for F with appropriate subscripts)

(11) $m_B \dfrac{\Delta v_B}{\Delta t} = -m_A \dfrac{\Delta v_A}{\Delta t}$ (the student substitutes $\Delta v/\Delta t$ for acceleration with subscripts on v's only)

(12) The student connects this last mathematical statement (or any additional correct mathematical statements) to the fact that an increase in B's momentum is the same as a decrease in A's momentum.

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F3. A heavy rope is set over a small, ideal pulley so that one end is a distance y higher than the other, as shown in the diagram. The rope has total length L and a mass-to-length ratio of μ (which would be measured in kilograms per meter). Suppose that the rope is released from rest in this configuration.

Part y

(a) Write expressions for the following in terms of L, y, μ, and fundamental constants.

L = Total Length
u = mass to length Ratio Kg/m

i. The total mass of the rope

Total mass = u(kg/m) * L(m)

ii. The mass of the piece of the rope of length y

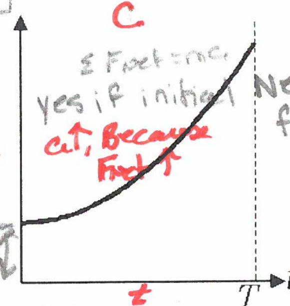
mass piece y = u(kg/m) y(m)

iii. The acceleration of the rope at the moment the rope is released, as a function of y

$F_T = mg$ (↑ Total Rope) $F_T = uLg$ | $F_T = ma$ (↑ mass y: uy) | $F_T = ma$, $m = uy$, $F_T = uLg$, $uLg = uya$, $a = \frac{Lg}{y}$

F_T ↑ ... y

(b) Let v represent the speed of one end of the rope and a represent the magnitude of the acceleration of one end of the rope. The rope is released at time $t = 0$ and the left end of the rope reaches the pulley at time $t = T$. Three students examine the graph shown to the right and offer the following statements:



C. ΣFnet = ma. yes if initial a↑, Because Fnet ↑. Net force. a. Initial Net force. t

Student A: "That graph could represent the length y as a function of time."
Student B: "That graph could represent the speed v as a function of time."
Student C: "That graph could represent the acceleration a as a function of time."

more Rope ∴ more Fw, ∴ ↑a

A   B

i. Which student(s) is/are correct? Mark the blank next to each correct student.

L (m), Δy, T   V, t — No, starts from Rest

Yes Student A NO Student B Yes Student C

ii. In a well-organized paragraph, explain why each correct student is correct, and what is wrong with the wrong students' statements.

A. There is an initial y, so the intercept is justified in the graph

B. There is NO initial velocity, so student B is wrong since the graph has an intercept

C. There is an initial a, Because there is initially a net force, so intercept is Justified
Also the acceleration ↑ Because as the Rope moves, the height differencey which ↑ the net force