AP Physics - Unit 2 - Dynamics
Tipper #1 - Unit 2

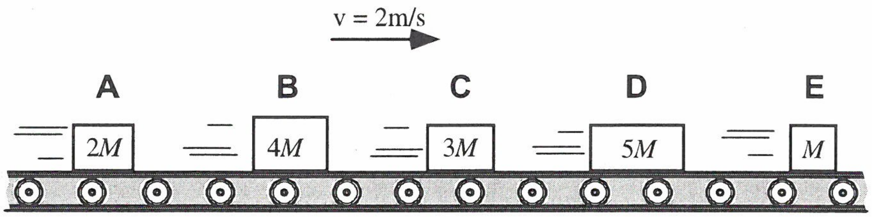
KEY

B3 NEWTON'S LAWS

#1

B3-RT01: PACKAGES MOVING ON A CONVEYOR BELT—NET FORCE

Various packages with different masses are moving on a constant-speed conveyer belt. At the instant shown below, all packages have the same constant velocity of 2 m/s directed to the right. The packages do not slip on the belt. All masses are given in the diagram in terms of *M*, the mass of the smallest package.



Rank the magnitude of the net force on each package.

					OR			
1 Greatest	2	3	4	5 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Answer: All Zero.

The net force on each package must be zero due to Newton's 1st Law since they are not accelerating (moving at a constant speed).

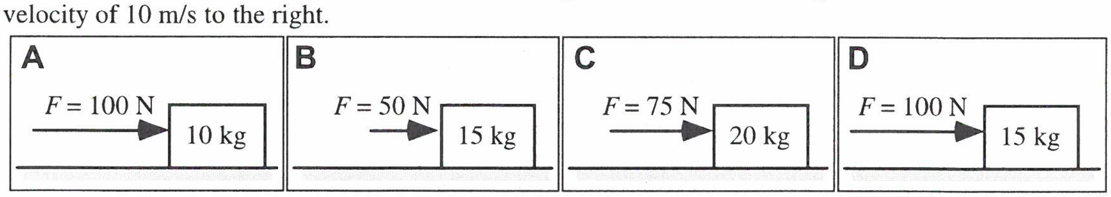
$\Sigma F_x = ma$ constant V ∴ $a = 0$

$F_x = ma \to 0$

#2

B3-RT08: FORCE PUSHING BOX—ACCELERATION

Various similar boxes are being pushed for 10 m across a floor by a net horizontal force as shown below. The mass of the boxes and the net horizontal force for each case are given in the indicated figures. All boxes have the same initial velocity of 10 m/s to the right.



Rank the acceleration of the boxes.

				OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

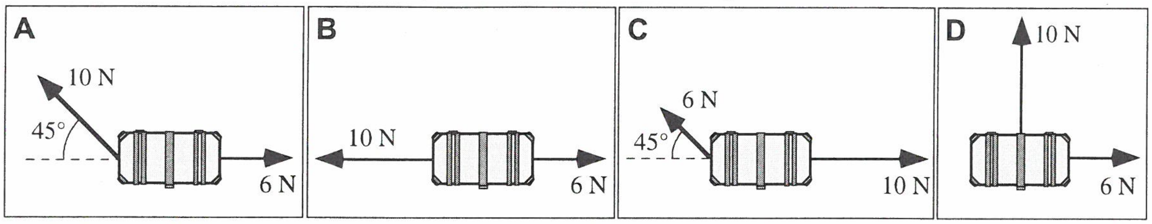
Answer: A > D > C > B

The acceleration equals the net force on each box divided by the mass of the block or a= Fnet/m using Newton's 2nd Law. For A, a = Fnet /m = 100 N/ 10 kg = 10 m/s²; for B, a = Fnet /m = 50 N/ 15 kg = 3.33 m/s²; for C, a = Fnet /m = 75 N/ 20 kg = 3.75 m/s²; and for D, a = Fnet /m = 100 N/ 15 kg = 6.67 m/s²

2/7

#3 **B3-RT10: TWO-DIMENSIONAL FORCES ON A TREASURE CHEST—FINAL SPEED**

Identical treasure chests (shown from above) each have two forces acting on them. All chests start at rest.



Rank the speed of the treasure chest after 2 seconds.

1 Greatest	2	3	4 Least	OR	All the same	All zero	Cannot determine
D	C =	A	B				

Explain your reasoning.

Answer: D > C = A > B.
We need to find the accelerations of the chests. Since they are all starting from rest and accelerating for the same time, the final speed will be proportional to the acceleration. The acceleration will be proportional to the net force, i.e., the vector sum of the two forces acting on each chest.

$A = \frac{\Sigma F}{m \leftarrow \text{same}}$ ∴ only F matters

A

6N → x

F_y, 10N, F_x

$\Sigma F_x = +6N - 10\cos 45°$

$\Sigma F_x = 1N$

$\Sigma F_y = 10\sin 45$
$= 7$

$R = \sqrt{1^2 + 7^2}$

$R = 7N$

2

B

$\Sigma F_x = -10N + 6N$
$= 4N$

3

C

$\Sigma F_x = 10N - 6N\cos 45°$

$\Sigma F_x = 6$

$\Sigma F_y = 6N\sin 45°$
$= 4$

$R = \sqrt{6^2 + 4^2}$

$R = 7$

2

D

$R^2 = 10^2 + 6^2$

$R = 12$

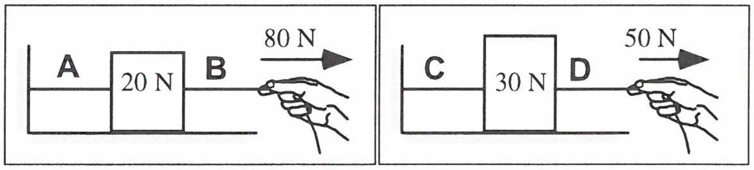
1

3/7

#4

B3-RT16: Blocks Attached to Wall—Rope Tension

Two blocks are attached by a rope to a wall. A child pulls horizontally on a second rope attached to each block. Both blocks remain at rest on the frictionless surface. The weights of the blocks and the magnitudes of the forces exerted by the child are given.



Rank the tensions in the ropes.

☐	☐	☐	☐	OR	☐	☐	☐
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Answer: B = A > D = C.

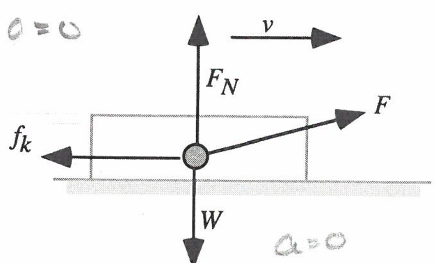
Since the blocks remain at rest, the vector sum of the forces on the blocks in the horizontal direction must be zero. So the tensions in the two ropes in the left case are both 80 N and the tensions in the right case are both 50 N.

#5

B3-WWT36: Pulling a Block Across a Rough Surface—Force Relationships

A person pulls a block across a rough horizontal surface at a constant speed by applying a force F at a slight angle as shown. A free-body diagram is drawn for the block. The arrows in the diagram correctly indicate the directions but not necessarily the magnitudes of the various forces on the block. A student makes the following claim about this free-body diagram:

∴ a = 0



"The velocity of the block is constant, so the net force acting on the block must be zero. Thus the normal force F_N equals the weight W, and the force of friction f_k equals the applied force F."

a = 0
Balanced Forces!

What, if anything, is wrong with this statement? If something is wrong, identify it and explain how to correct it. If this statement is correct, explain why.

Answer: The statement is wrong.

The block is not accelerating, so the student is right that there is no net force, that means the sum of the vertical forces is therefore zero and the sum of the horizontal forces is also zero. Thus the horizontal component of F must be equal to the frictional force ($F\cos\theta = f_k$), and the weight must equal the normal force plus the vertical component of the applied force F ($W = F_N + F\sin\theta$).

$\Sigma F_x = F\cos\theta - F_{fk} = ma^{0}$

$F_{fk} = F\cos\theta$

$\Sigma F_y = F_n - F_w + F\sin\theta = ma^{0}$

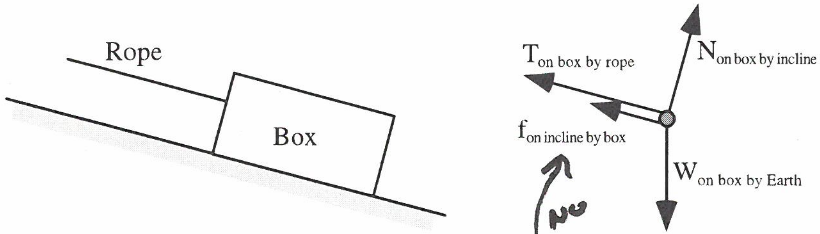
$F_n = F_w - F\sin\theta$

4/1

#6

B3-WWT43: Box on Incline—Forces

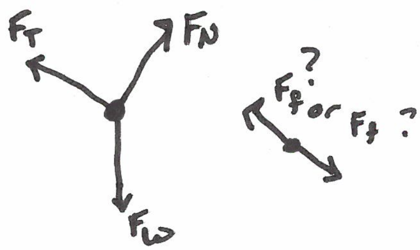
A heavy box is sitting at rest on an incline. There is friction between the box and the incline, and a rope is pulling on the box in a direction up and to the left, parallel to the incline. A physics student draws the free-body diagram below right for the box.



What, if anything, is wrong with this student's free-body diagram? If something is wrong, explain the error and how to correct it. If this free-body diagram is correct, explain why.

Answer: The force acting on the incline by the box does not belong in the free-body diagram of the box. Only forces acting on the box can be in this free-body diagram. There should be a vector representing the friction force on the box by the incline, and this force should be parallel to the surface, but we don't have enough information to tell whether it points up the incline or down the incline. (Also if the free-body diagram was supposed to be to scale, the sum of the forces as drawn is not zero as it should be since the box is at rest -- there is a net force up the incline.)

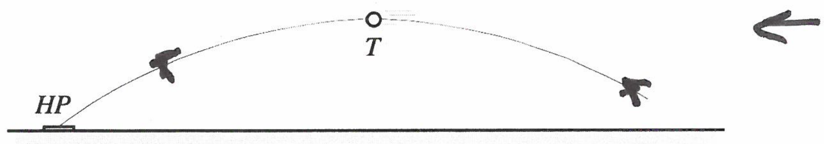
Currently in Diagram



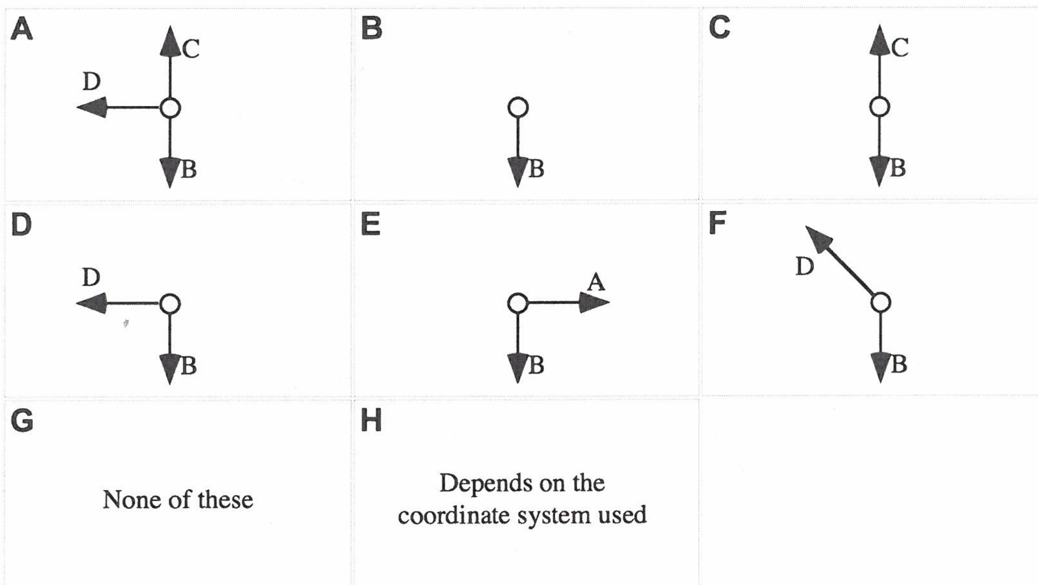
#7

B3-QRT42: THROWN BASEBALL—FREE-BODY DIAGRAM AT THE TOP

A baseball is thrown from right field to home plate (HP), traveling from right to left in the diagram.



A group of physics students watching the game create the following free-body diagrams for the baseball at the top of its path (point T). Note that the forces are not drawn to scale.



(a) If they decide to *ignore air friction,* which is the correct free-body diagram for the baseball at point *T*?

B, The only force acting is the weight of the ball since we are ignoring friction.

(b) Define all forces on the ball for this force diagram.

B is the gravitational force on the baseball by the earth (i.e., the weight of the baseball).

(c) If they decide to *include air friction,* which is the correct free-body diagram for the baseball at point *T*?

Diagram E includes air friction (A) acting opposite to the direction of motion, and the force of gravity (B).

(d) Define all forces on the ball for this force diagram.

B is the gravitational force on the baseball by the earth (i.e., the weight of the baseball) and A is the frictional force on the baseball by the air.

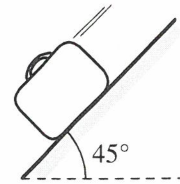
6/7

#8

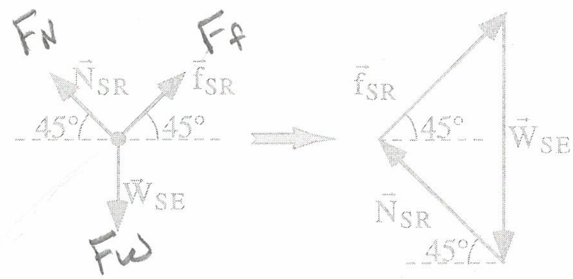
B3-CRT45: Suitcase Sliding Down Ramp at Constant Speed—Forces on Suitcase

A suitcase is moving at a constant speed as it slides down a ramp angled at 45° to the horizontal.

∴ a=0 Balanced forces !!



Draw a free-body diagram below, labeling and defining all the forces on the suitcase.



FN - Normal force By surface ON suitcase

Ff - friction Between suitcase & ramp

Fw - gravitational force exerted ON suitcase

Rank the magnitudes of these forces on the suitcase.

$W_{SE} > N_{SR} = f_{SR}$

N & Ff equal since constant V

Fw greater since moving

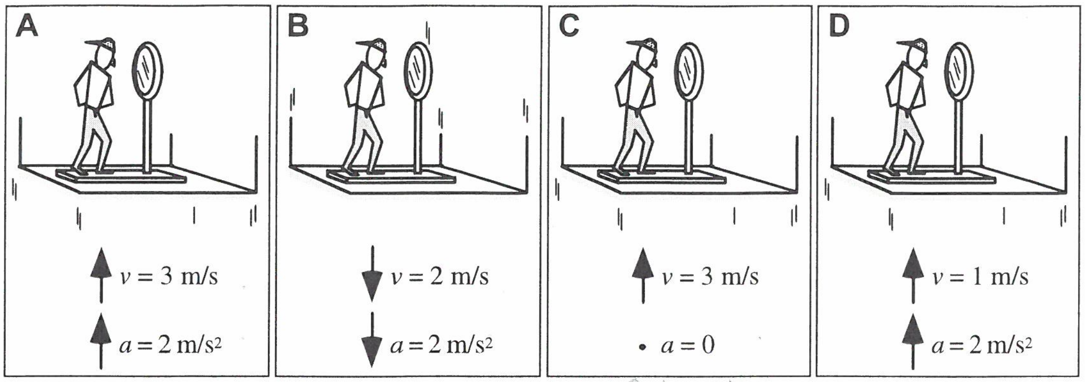
Explain your ranking.

The suitcase is not changing speed or direction, so the net force on the suitcase must be zero. From the vector sum diagram, we see that the weight is the hypotenuse of a triangle, and so the weight is the largest force. Since the triangle is isosceles (45°, 45°, 90°), the normal force and the friction have equal magnitude.
(The coefficient of friction in this case must be 1, since the coefficient of friction is the ratio of the friction force to the normal force.) Note that N_{SR} means normal force exerted by the surface on the suitcase, W_{SE} indicates the gravitational force exerted by the earth on the suitcase, and f_{SR} is the friction force by the ramp on the suitcase.

#9 **B3-RT60: PERSON IN A MOVING ELEVATOR—SCALE READING**

7/7

A person who weighs 600 N is standing on a scale in an elevator. The elevator is identical in all cases. The velocity and acceleration of the elevators at the instant shown are given.



Rank the scale reading.

Balanced forces

1 Greatest	2	3	4 Least	OR	All the same	All zero	Cannot determine

$F = ma$

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

$\Sigma F_y = F_n - F_w = ma$

$F_n = ma + F_w$

Explain your reasoning.

Answer: A = D > C > B. $F_N = ma + F_w$

The scale is providing the normal force on the person, and the scale reading indicates the magnitude of this force. For cases A and D that normal force is larger than the person's weight because the scale also has to accelerate the person upward. For case C the normal force is equal in magnitude to the person's weight, and for case B it is less than the person's weight since the person is accelerating downward.

A & D
Both $a = 2$
$F_N = ma + F_w$
↑ Same Always ↑ same
$F_n = 2m + F_w$

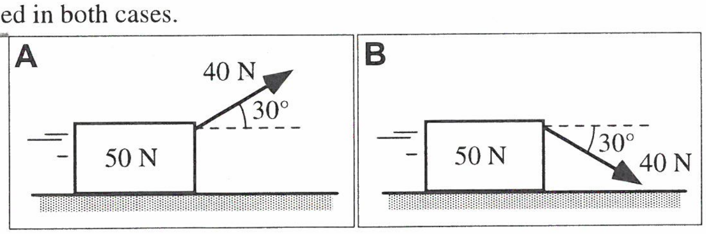
C
$a = 0$
$F_n = F_w$

B
$a - 2$
$F_n = -2m + F_w$

#10 **B3-CT87: BOX MOVING OVER HORIZONTAL SURFACE—FRICTIONAL FORCE ON BOX**

A 50 N box has an applied force on it of 40 N that makes an angle of 30° with the horizontal. The box is moving to the right at a constant speed in both cases.

$a = 0$
Balanced forces

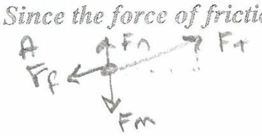


Will the frictional force exerted on the box by the rough surface be (i) *greater* in Case A, (ii) *greater* in Case B, or (iii) *the same* in both cases? _____

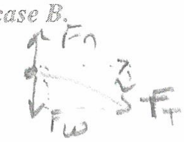
Explain your reasoning.

coefficient of friction = How Rough a Surface is

Answer: Greater in case B.
The boxes are not accelerating vertically, so the net vertical force must be zero. The tension in the string in Case A has an upward vertical component, reducing the normal force required to balance the weight of the box. In Case B the tension has a downward vertical component, so the normal force must be greater than the weight. Since the force of friction is proportional to the normal force, the frictional force is greater in case B.



$f_f = \mu F_n$



$\Sigma F_x = F_T \cos 45 - F_f = ma^0$
$F_f = F_T \cos 45$

$\Sigma F_y = F_n + F_T \sin\theta - F_w = ma^0$
$F_n = F_w - F_T \sin\theta$
Reducing force

$\Sigma F_y = F_n - F_T \sin\theta - F_w = ma$
$F_N = F_T \sin\theta + F_w$
↑ Addining in more force