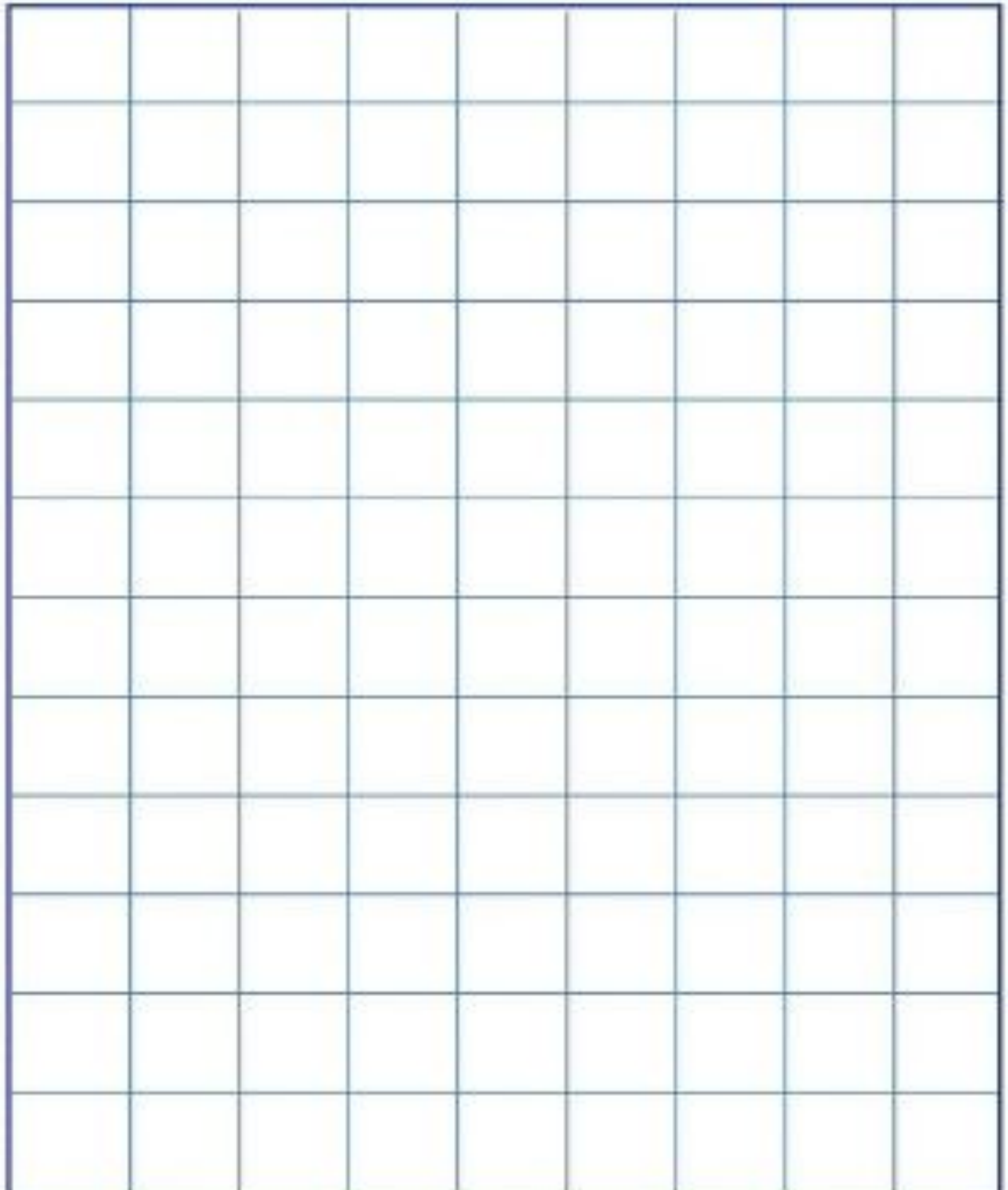
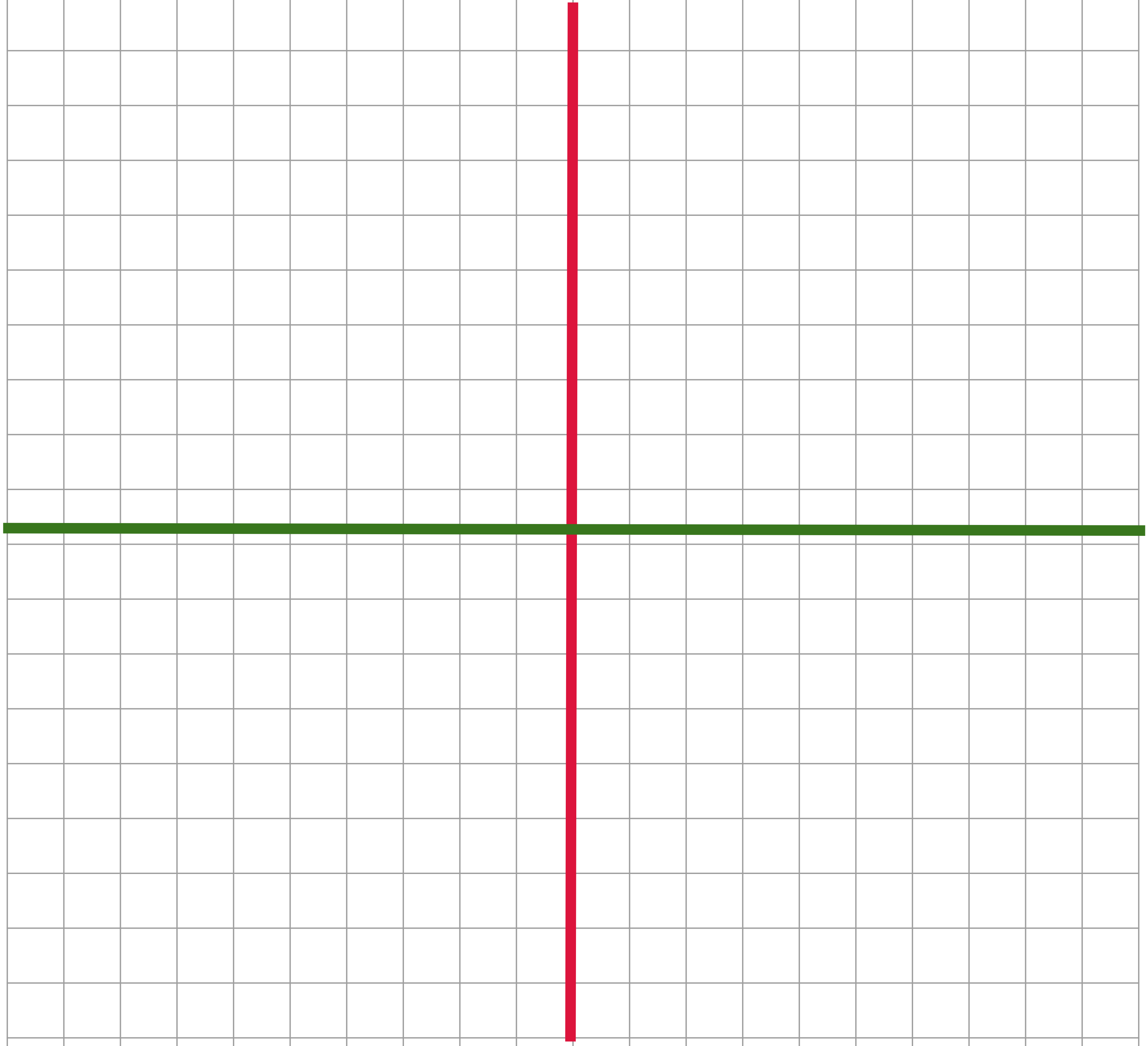
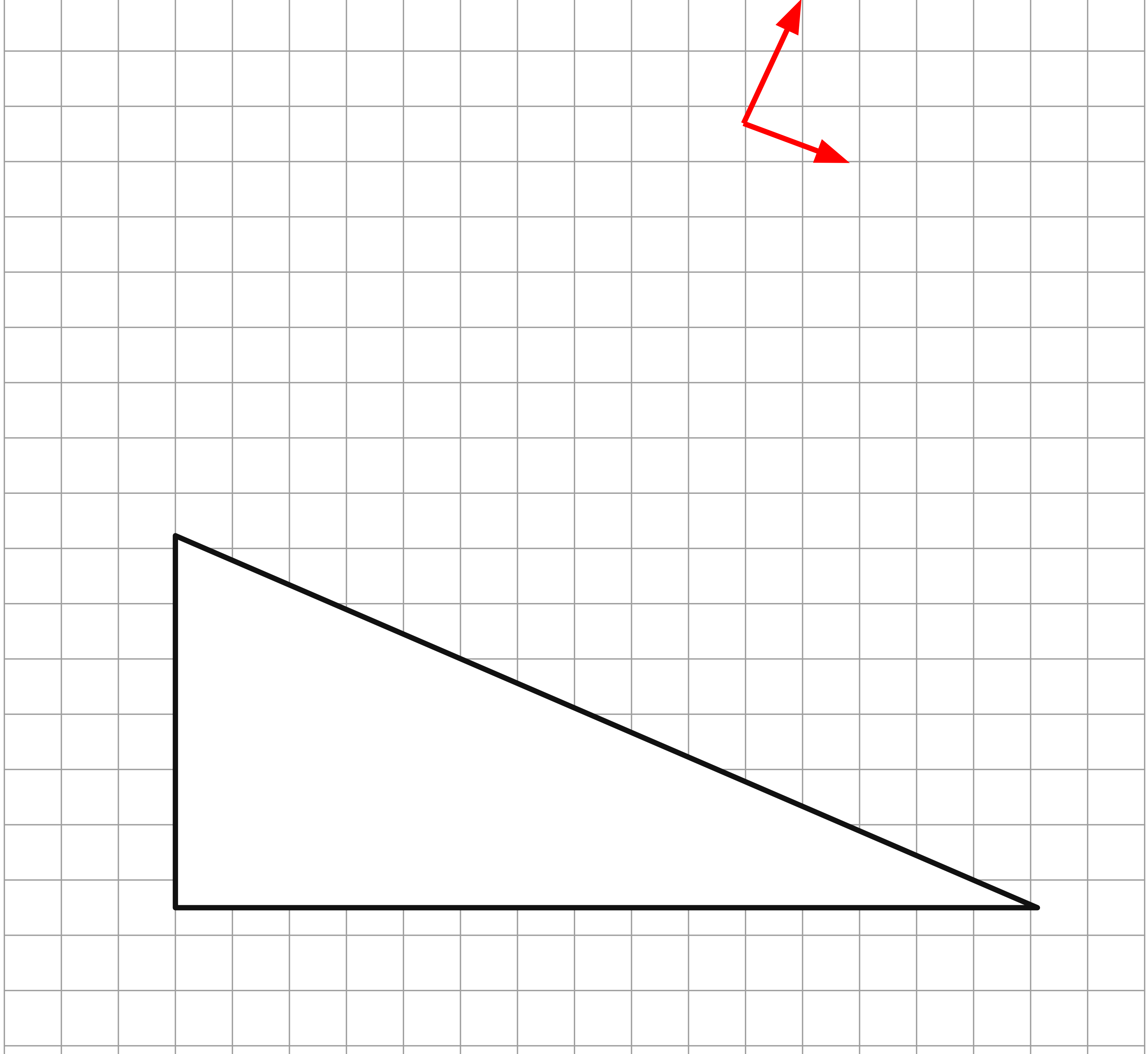






Poll #1

I would characterize my emotional state right now as:

A. Terror
B. Excitement
C. Indifference
D. Fear of the Unknown
E. NOTA (cyborg, etc…)

Poll #2
My primary goal for this class is to

A. Acquire some intuition about physics
B. Get an “A”, independent of how much I learn

Poll #3: I expect to put in how many hours on lecture weekly outside of lecture time?

A. <5
B. 5-10
C. 10-15
D. 15-20
E. >20

"The moral arc of history is long, but it bends towards justice"

A) Agree

B) Disagree

C) What's a 'moral arc'?

D) Who cares?

A good instructor is one that gets good evaluations

A) Strongly agree

B) Agree

C) Neutral

D) Disagree

E) Disagree strongly

"Learning" is ultimately the responsibility of:

A) The instructor

B) The student

Compared to being in-class, I learn X% from being online

A) more online than in-person
B) the same online than in-person
C) 80% of what I would in-person
D) 60% of what I would in-person
E) less than 60%

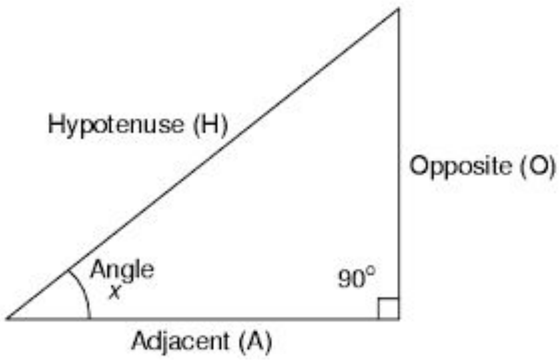
Compared to real-time, I learn X% from recorded videos

A) more
B) the same
C) 80%
D) 60%
E) less than 60%

Trig review

A) All based on right triangles

B) Either: a) find the components, given a hypotenuse and an angle X (not the 90° angle!) , b) find the hypothenuse, given the components



C) To memorize: sin(X)=(opposite length)/(hypotenuse length)

D) cos(X)=(adjacent length)/(hypotenuse length)

E) tan(X)=(opposite length)/(adjacent length) (SOH-CAH-TOA)

F) Must put in positive/negative signs after fact!

Vidad stared blankly into space. If he could just find 3.78 megadenegs, he'd have enough to buy a sporty XZ Coupe to escort Nire to the Zolar planetary festival of Physics, where they would almost certainly be crowned Korona and Korolla Physic, the most prestigious title on Zolar. Although he had no denegs, he did have a sphere of zolota 44 cm in radius. If each cubic mm of zolota is worth 14 denegs, then:

A) Vidad wins the heart of the beautiful Nire
B) Vidad's power play crashes and burns
C) Need more information

Displacement, velocity, acceleration

x=position, $x_f - x_i$="x-displacement", etc.

$$\Delta t=(t_f-t_i);\ \Delta x=(x_f-x_i)$$

$$x_f=x_i+v_{i,x}\,\Delta t+a_x(\Delta t)^2/2$$

$$v_{f,x}=v_{i,x}+a_x\Delta t;\ x_f=x_i+v_{x,i}\Delta t$$

$$y_f=y_i+v_{i,y}\,\Delta t+a_y(\Delta t)^2/2$$

$$v_{f,y}=v_{i,y}+a_y\Delta t;\ y_f=y_i+v_{y,i}\Delta t$$

$v_f^2=v_i^2+2a(\Delta x)$ (from energy conservation...)

Laika (the uber-dog) is initially running in the -x-direction with a velocity of 2 m/s in magnitude. What is Laika's displacement after six seconds if his acceleration is +3 m/s^2?

A) -42 m

B) 42 m

C) 66 m

D) -66 m

E) NOTA

A ball is thrown vertically upwards from a height of 1.3 m; the initial velocity magnitude is 5 m/s. After solving for time, what is the highest point the ball reaches, above ground?

A) 1.28 m

B) 2.57 m

C) 3.86 m

D) 4.51 m

E) NOTA

A mass has an acceleration of magnitude 5 m/s^2 that makes an angle of -36.9^o wrt -x. Starting from rest, how far does the mass move, along x-, and y-, in 2 seconds?

A) 10 m, 10 m

B) -8 m, +6 m

C) -6 m, +8 m

D) -8 m, -6 m

E) NOTA

Which of the following, in general, is true?

A) At a given time, displacement, velocity and acceleration can all be either positive or negative, independent of each other.

B) Displacement and velocity must have the same sign, but acceleration can be opposite

C) Velocity and acceleration must have the same sign, but displacement can be opposite

D) NOTA

In 1948, John Stapp decelerated from 632 mph to rest in 1.4 s (resulting in hemorrhaging of the vessels in his retina). His total g-force is about

A) 28.66 g

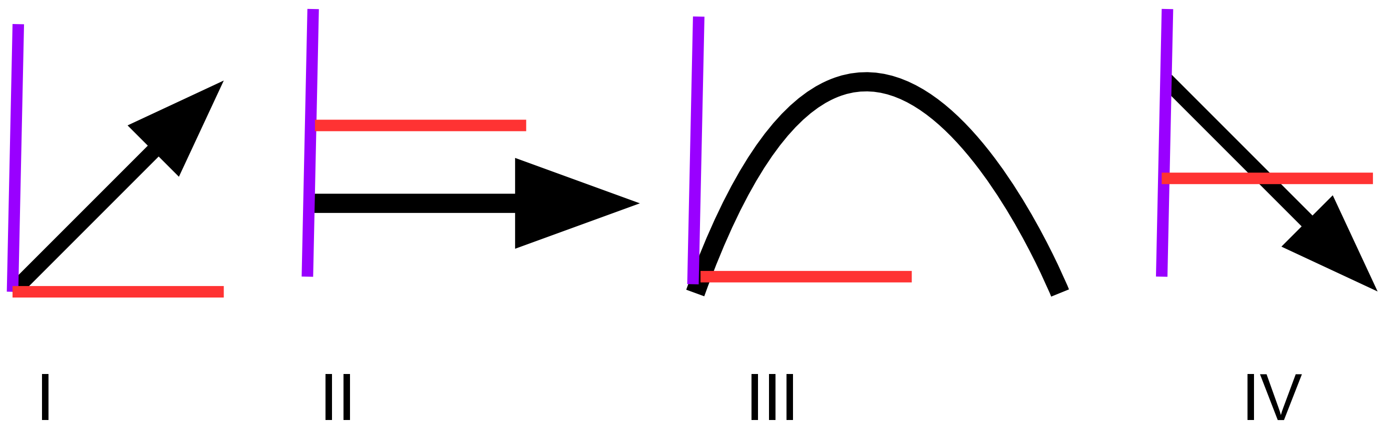
B) 37.76 g

C) 1088.4 g

D) 1.6 g

E) NOTA

A ball is thrown vertically upwards off the Palisades Cliffs. Assuming the horizontal axis is time, and the origin is (0,0), which of the diagrams shown best depict the shape of the curves expected for the ball's velocity v(t) and acceleration a(t), respectively?



A) I, III

B) IV, II

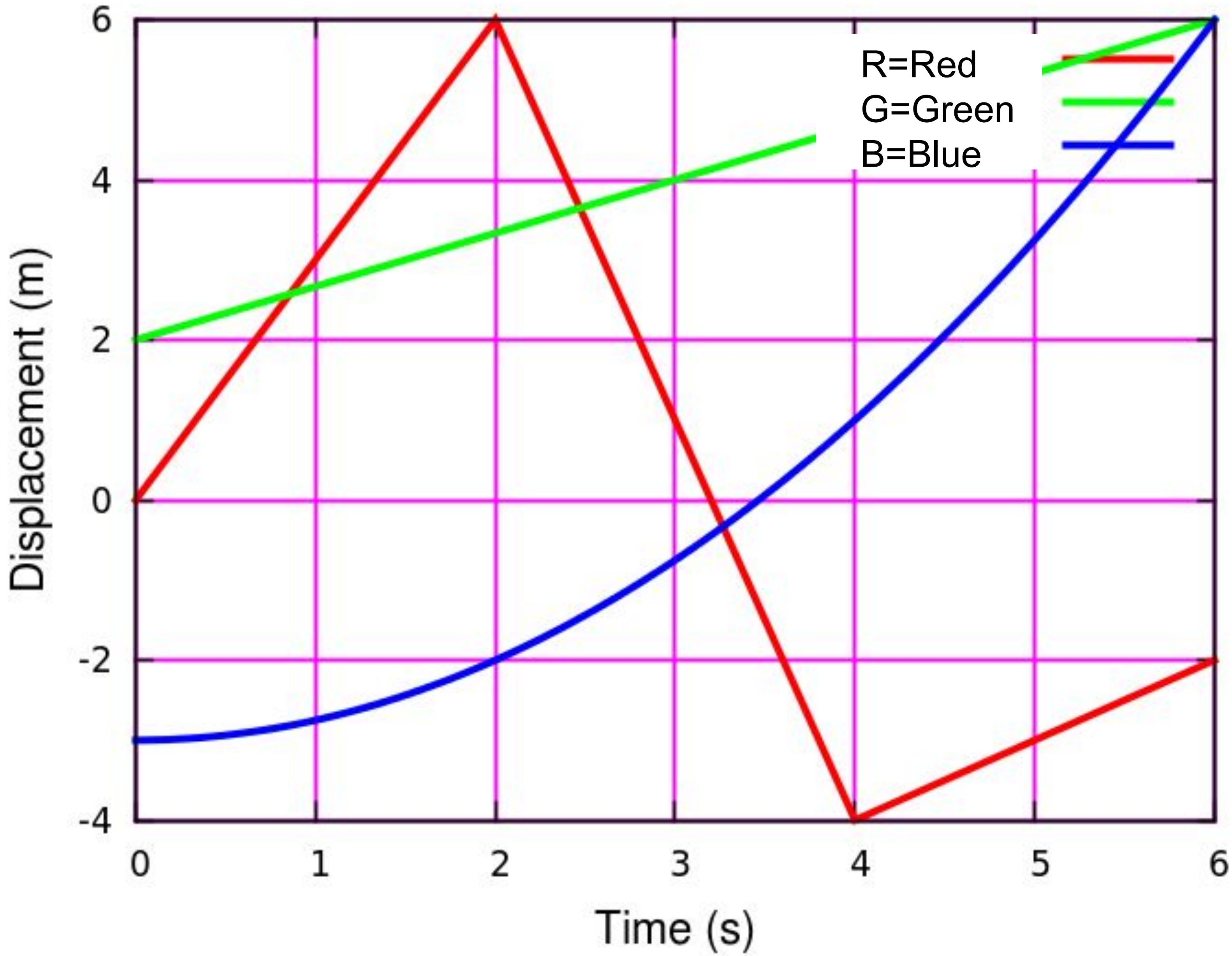
C) I, IV

D) II, III

E) NOTA

A) 1) Over the first second, the velocity ranking is (most positive to most negative): A) RGB B) GRB C) BGR D) NOTA

B) 2) For 4s<t<6s, the “red” acceleration is A) >0, B)<0, C)=0



3) The blue velocity at t=4 seconds is approximately

A) 1 m/s

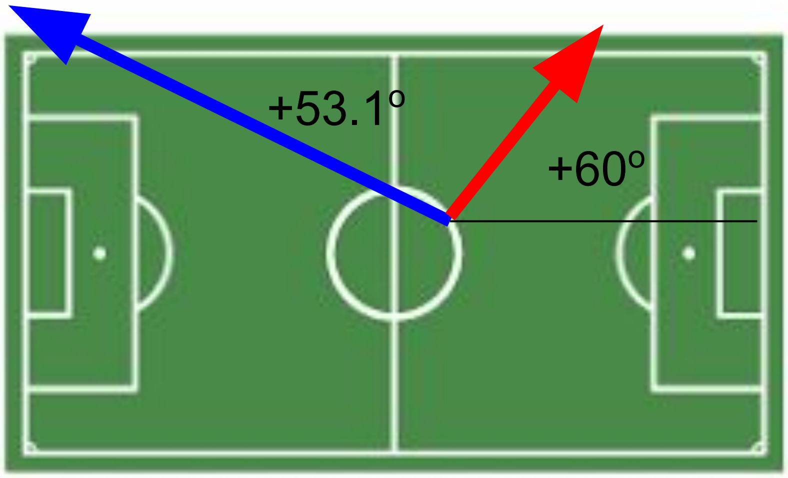
B) 2 m/s

C) 0.5 m/s

D) 4 m/s

CAP-1/Q1

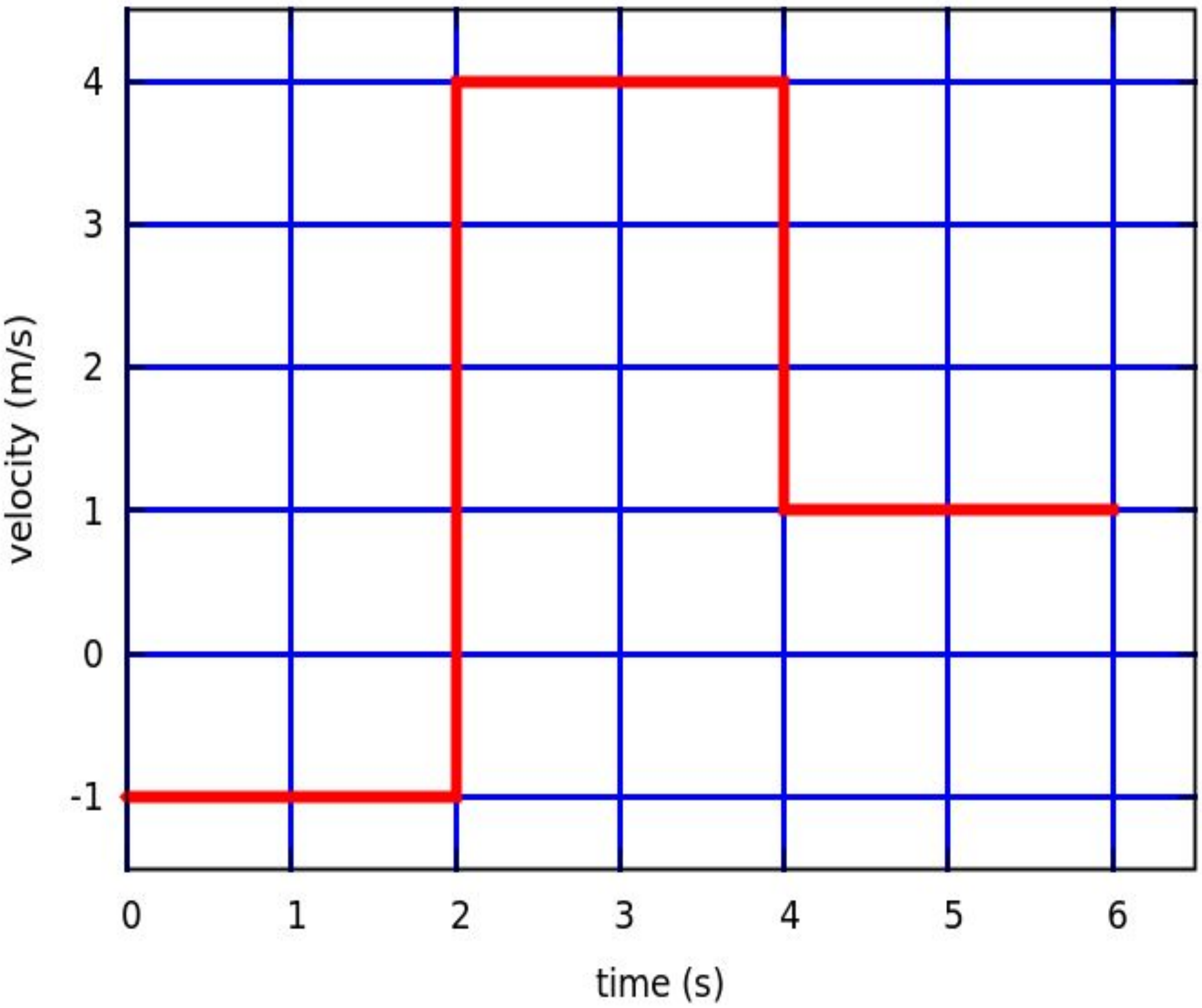
N. Benzina. kicks a soccer ball, starting from midfield, with a velocity of magnitude **v** (m/s) and an angle **X** (degrees) relative to the **+x/+y/-x/-y**-axis. Owing to the peculiarities of astro-turf, assuming the soccer ball has an acceleration of **a**, making an angle of **Y** (degrees) relative to the **+x/+y/-x/-y**-axis (m/s^2), determine how far the ball moves in the x- and y-directions, respectively, after a time **t** seconds, the total displacement from it's starting point (m).



Now insert values:

1) $x_i=0$; $y_i=0$ at midfield
2) Assign: $|v|=20$ m/s, $\theta_v=+53.1^o$, relative to +y
   $|a|=2$ m/s^2, $\theta_a=+60^o$, relative to +x
3) Solve problem for t=1.8 seconds

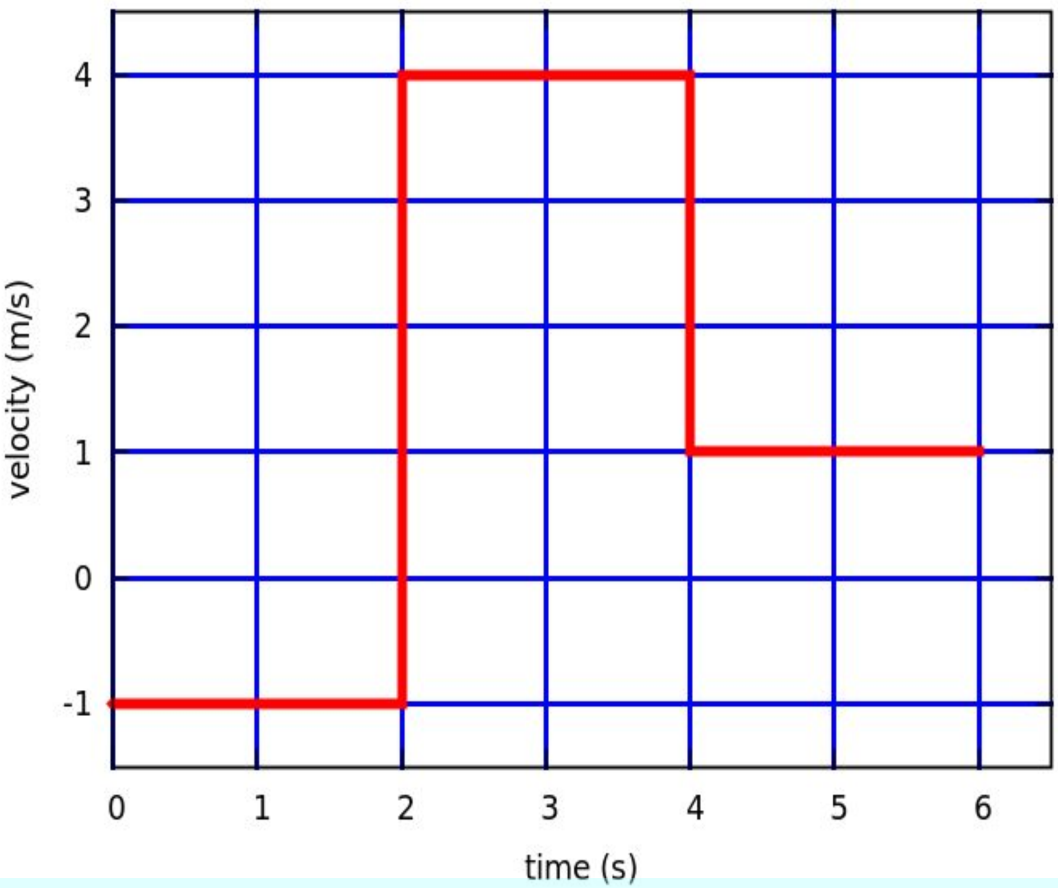
If x_i=-6 m, then given the v(t) curve shown, x_f(t=4s)=



A) 6 m
B) 4 m
C) 2 m
D) 0 m
E) NOTA

For the same v(t) curve, the magnitude of the displacement is maximal at

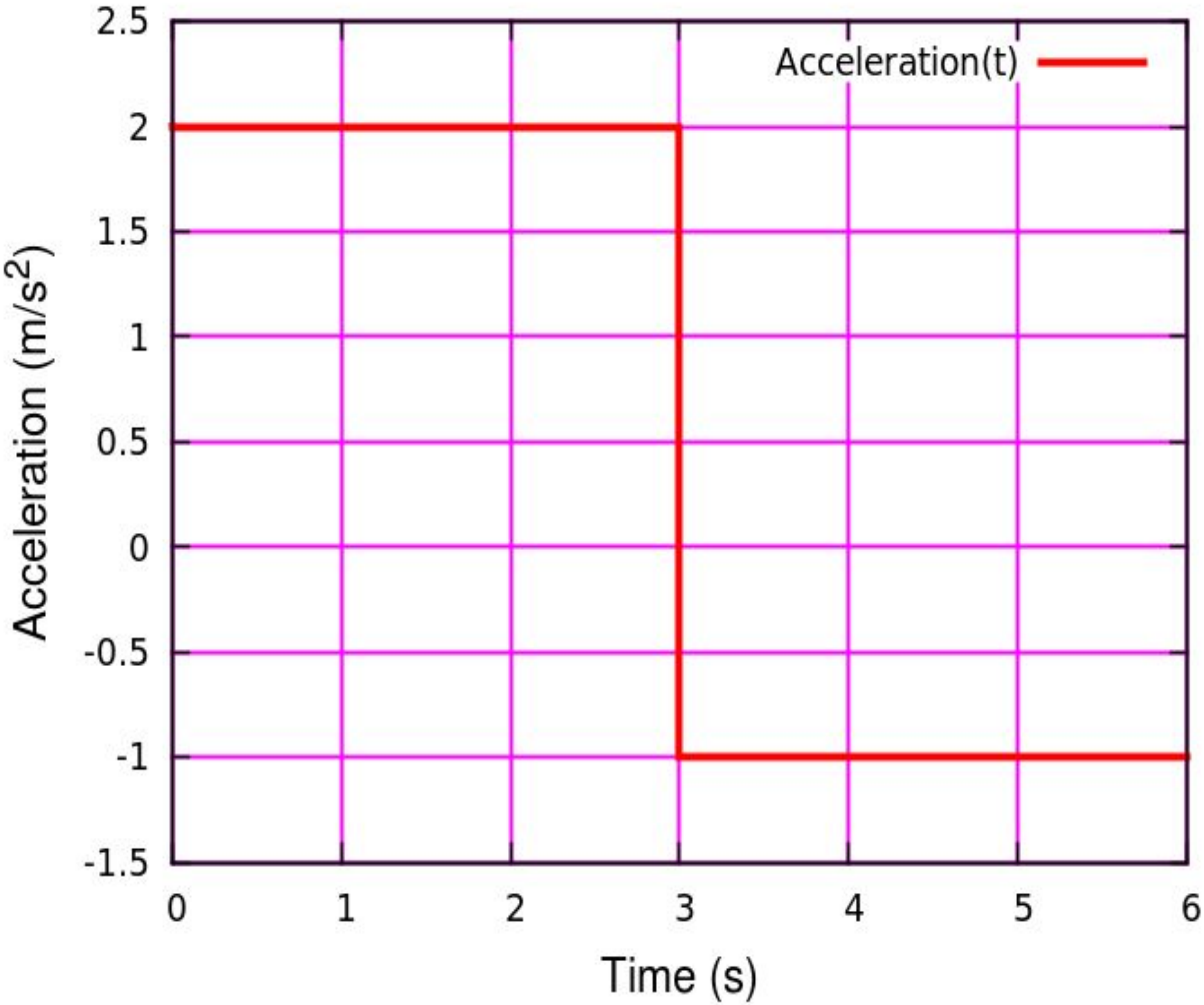
A) 6 s
B) 4 s
C) 2 s
D) 0 s
E) NOTA



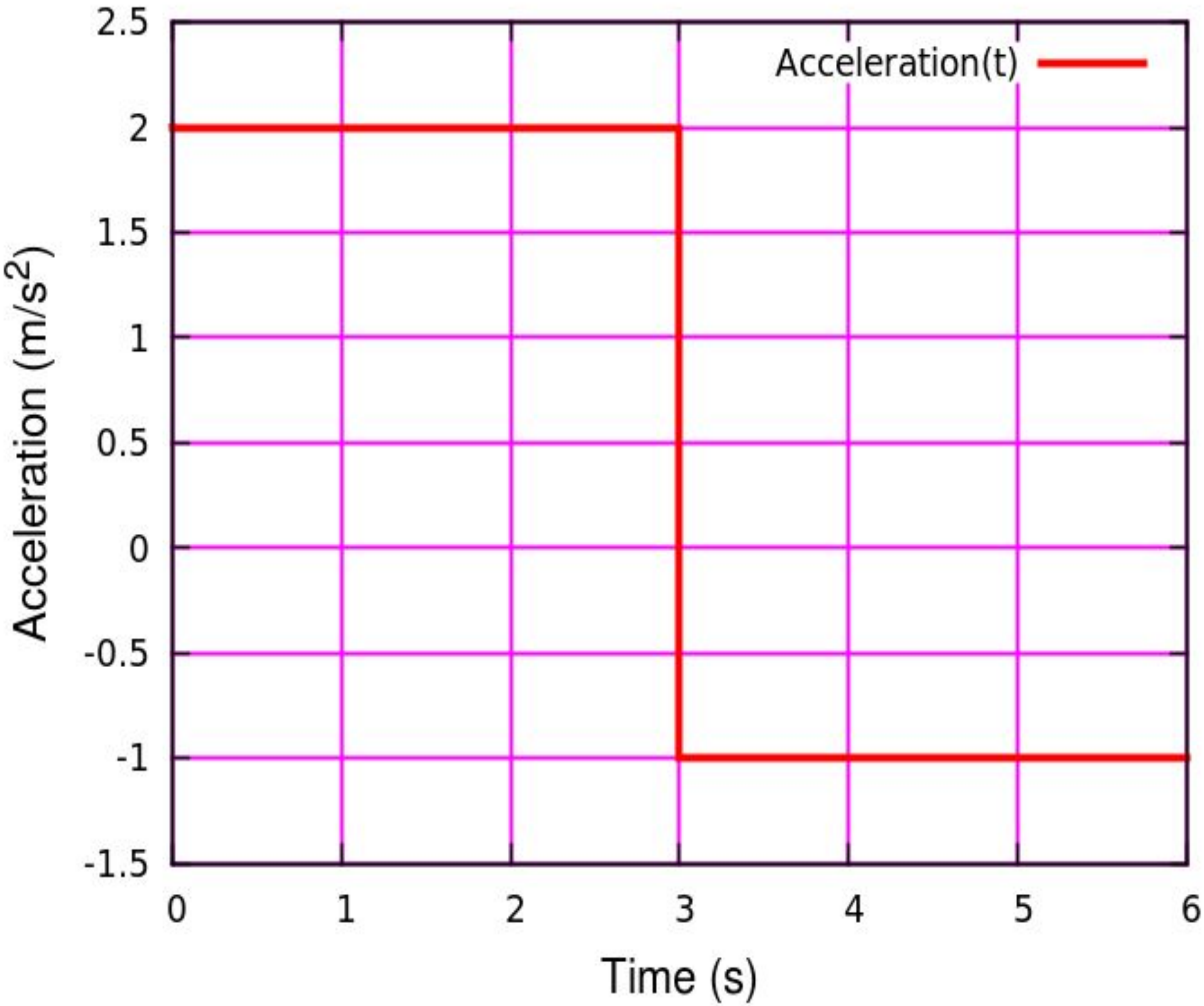
If the sketch were 'inverted' (i.e., all neg↔pos), the magnitude of the net displacement would:
A) increase B) decrease C) remain the same

Given the acceleration vs. time graph shown, assuming v(t=0 seconds)=-2 m/s, what is the velocity at t=3 s and also t=6 s?

A) 4 m/s, -1 m/s
B) -1 m/s, 1 m/s
C) 4 m/s, 1 m/s
D) 6 m/s, 3 m/s
E) NOTA



If x_i=-2 m and v_i=-2 m/s, what is Δx at t=6 s?



A) -0.5 m

B) 0.5 m

C) 8.5 m

D) -8.5 m

E) NOTA

Draw a curve of x(t). Now exchange it with a neighbor, who will determine: a) total displacement, b) v(t) curve corresponding to the x(t) curve you just drew, d) a(t) curve corresponding to the v(t) curve you just drew

Fearless Leader Kim-Jong Un, playing 1-on-1 with DeeJay Tee, throws a basketball from $(x_i,y_i)=(0,0)$, with $|v|=20$ m/s, and making an angle of -53.1° wrt $-x$. Determine the final x-position (in meters), assuming it starts and ends on the ground.

Fearless Leader Kim-Jong Un, playing 1-on-1 with DeeJay Tee, throws a basketball from $(x_i,y_i)=(0,0)$, with $|v|=20$ m/s, and making an angle of -53.1^o wrt $-x$. 1) Determine the final x-position (in meters), assuming it starts and ends on the ground 1) without wind, 2) assuming there is wind v_{wind} blowing at 10 m/s in $+x$. 3) Same problem, assuming FLKJU is running in $-x$ direction at 10 m/s at release, with no wind

Fearless Leader Kim-Jong-Un, running at |v|=4 m/s in the +x-direction, throws a basketball from (0,0) at the basket (located at (x,y)=(30,40)). If the ball has |v|=10 m/s relative to *his hands* and is thrown in the direction of the basket, what is the basketball's approximate |v| relative to the ground?

A) 8.0 m/s
B) 10.1 m/s
C) 12.8 m/s
D) 18.9 m/s
E) 16.12 m/s

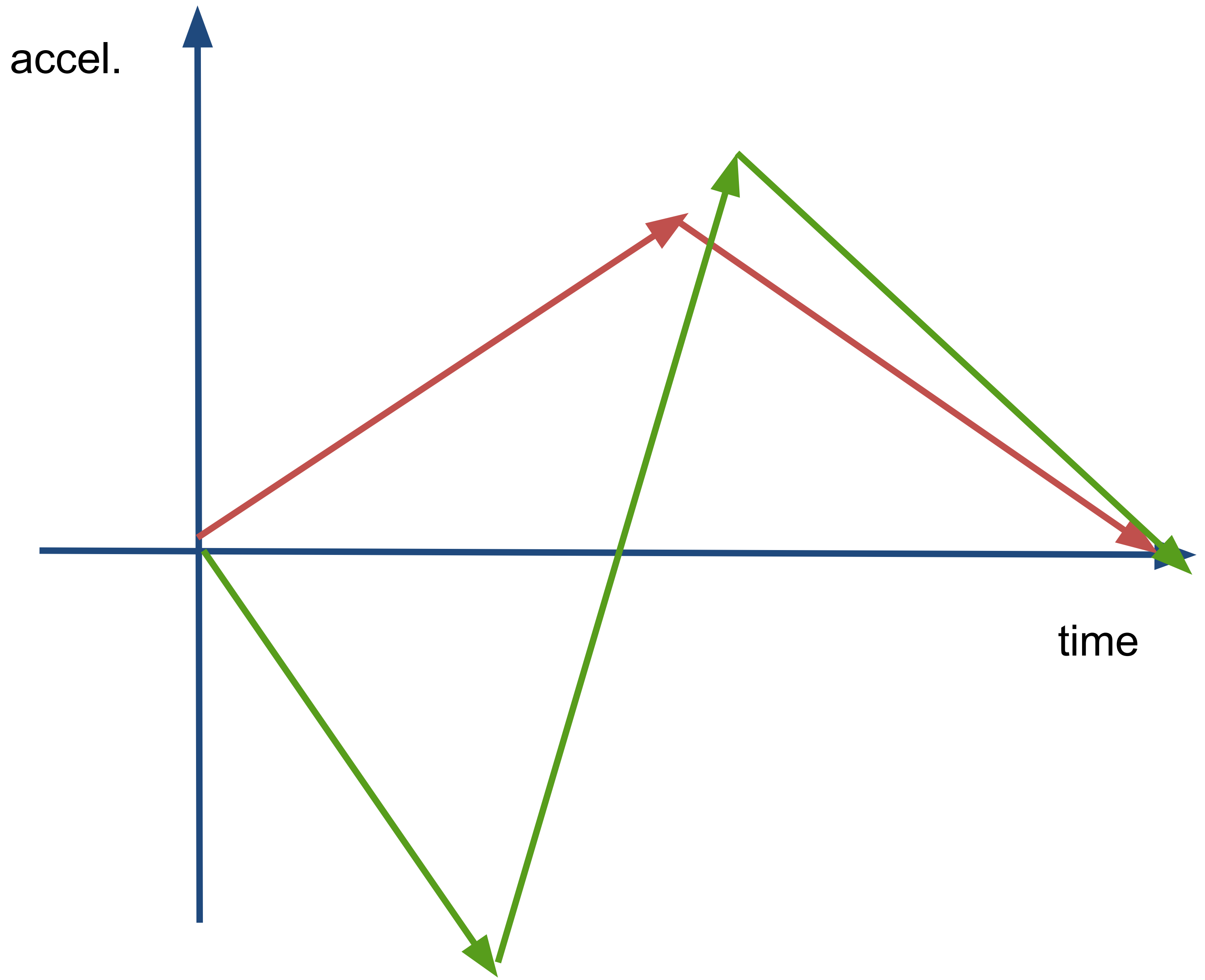
Golfer A hits a ball with 10% more upward, and 20% less horizontal velocity than golfer B. Which statement is true?

A) Golfer A's ball is in the air longer than golfer B.

B) Golfer B's ball is in the air longer than A.

C) They are in the air the same time.

Which of the following would lead to the largest Δv?



A train passes through a 200 m long station. If v_i=23.5 m/s, and it decelerates at a rate of 0.15 m/s^2, what is its velocity after emerging from the station?

A) 22.2 m/s

B) 24.7 m/s

C) 112 m/s

D) 13.1 m/s

E) NOTA

In the previous problem, how long is the train in the station?

A) 12.21 s
B) 19.14 s
C) 8.76 s
D) 0.114 s
E) NOTA

Moving backwards at a speed of 3 m/s, MC throws a pass, at an angle of +53.1° wrt the ground, to a player (on his own team); after 1.6 s, the ball is caught at the same height it was thrown from.

A) 1) The ball's initial $v_{y,ground=}$ **A) 9.8 m/s B) 7.84 m/s C) 5.88 m/s D) 8.88 m/s E) NOTA**

B) 2) $|v_{i,ground}|=$

C) 3) $v_{x,ground}=$

D) 4) $v_{x,hand}=$

E) 5) How far does the ball travel downfield? **A) 16.7 m B) 10.2 m C) 24.5 m D) 9.4 m E) NOTA**

Relative Velocities/Vector Addition

Zeke Cicero, albino elephant extraordinaire’, starts sailing due East from Atlantic City at 10 m/s; he encounters an 8 m/s wind blowing at -30^{o} relative to North. Qualitatively, which of the following statements is true?

A) Relative to Atlantic City, the wind increases his net velocity
B) Relative to Atlantic City, the wind decreases his net velocity.
C) Relative to Atlantic City, the wind leaves his net velocity unchanged.

Relative Velocities

Zeke Cicero, albino elephant extraordinaire', starts sailing due East from Atlantic City at 10 m/s; he encounters an 8 m/s wind blowing at -30° relative to North. Quantitatively, what is his approximate velocity relative to the shore?

A) 12 m/s
B) 16 m/s
C) 20 m/s

Force Vector A is 5 N, at an angle of -22.5° relative to -x, B=8 N, at θ=+67.5° relative to -y, and C=6 N, at θ=+45° wrt +x (c.c. is "positive"). |R| is about:

A) 0 N
B) 4 N
C) 7 N
D) 12 N
E) 16 N

The angle that R makes, wrt +y, is closest to:

A) +30° B) -30°
C) +120° D) -60°

Vector A is 2 Newtons, at an angle of $+60^o$ relative to -x, B=4 N, at $\theta=-20^o$ relative to +x, and C=4 N, at $\theta=-10^o$ wrt +y (c.c. is "positive"). The resultant R=A+B-C and the angle that R makes relative to the +x-axis

A) 2 N, 120^o
B) 11 N, 60^o
C) 7 N, -80^o
D) 4 N, 0^o

Given vectors v_i ($t=0$ s) and v_f ($t_f=4$ s). The acceleration vector is closest to:

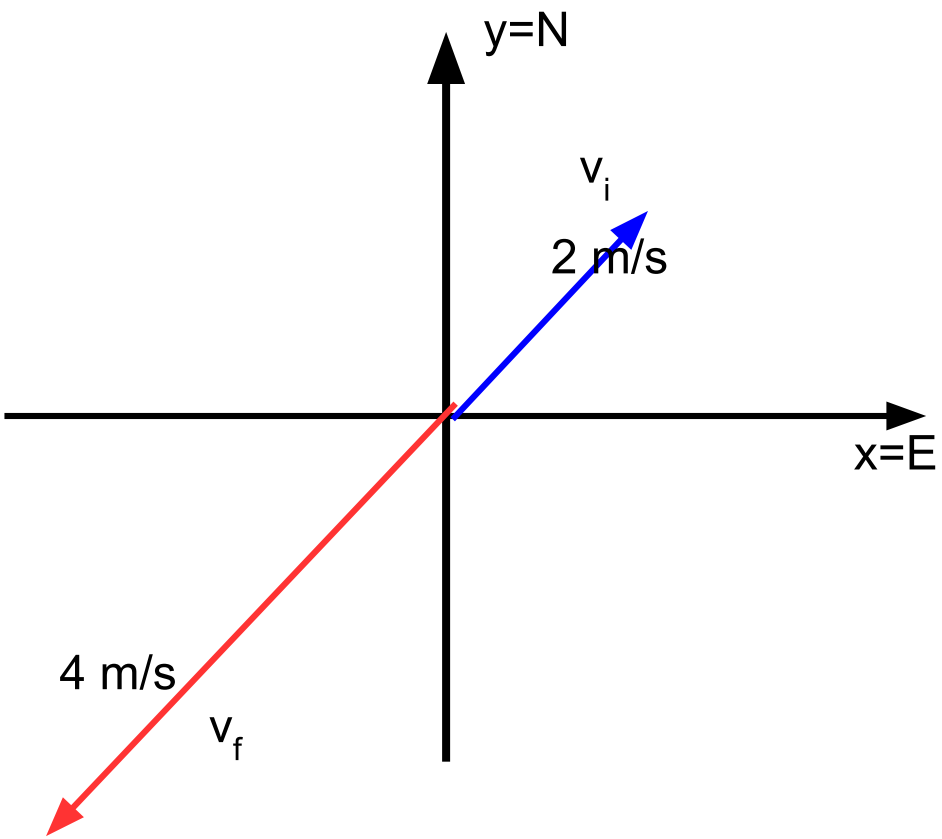
A) 6 m/s^2, NE

B) 2 m/s^2, NE

C) 1.5 m/s^2, SW

D) 0.5 m/s^2, NE

E) 4 m/s^2, SW



If v_f were parallel to v_i, then your calculated acceleration would: A) increase, B) decrease, C) be unchanged

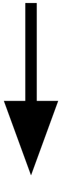
Draw two vectors of arbitrary length pointing in arbitrary directions, but with the angles between the vectors and the y-axis given in the problem, and the lengths of the vectors also given, with the tails at the origin. b) Graphically draw the resultant of A+B and also A-B on your page, c) numerically calculate the resultant of A+B on your page.

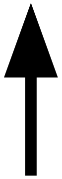
F=ma: use graphical addition of vectors to verify F=ma and show that all forces 'add up'

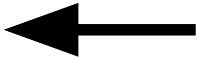
MAKE SURE FIRST VECTOR TAIL LINES UP WITH MASS BEING ACTED ON!!!

For inclined plane problems, define +x as *up* along incline (i.e. simple rotation of standard xy-axes)

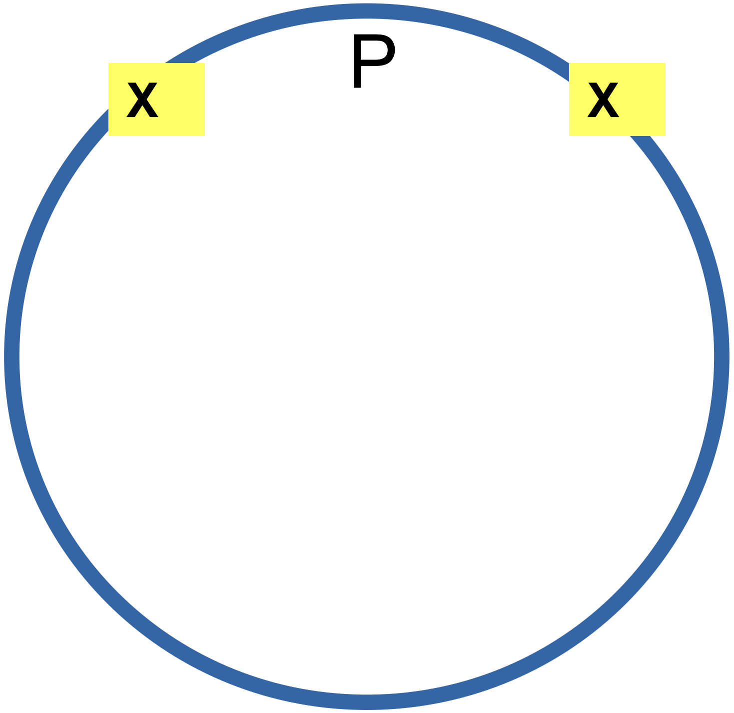
An object moves in a cc. circle. From the vector equation $\mathbf{a}=(\mathbf{v}_f-\mathbf{v}_i)/dt$, find the direction of **a** at P by drawing the direction of **v** just before and after P.

A) 

B) 

C) 

D) 



Three forces act on a mass: F_1 has magnitude 6N, at +60° wrt +x; F_2 has magnitude 4 N, at -30° wrt -x. If the mass is at rest, the magnitude and direction of the 3rd force F_3 **is about:**,

A) 2 N
B) 4 N
C) 7 N
D) 10 N

b) numerically determine the x and y-components of F_3

Laika accelerates, from rest, to 900 m/s in 45 seconds. The average force of the rocket ship on Laika is about:

A) $2 \times F_{grav}$

B) $3 \times F_{grav}$

C) $5 \times F_{grav}$

D) $10 \times F_{grav}$

E) $20 \times F_{grav}$

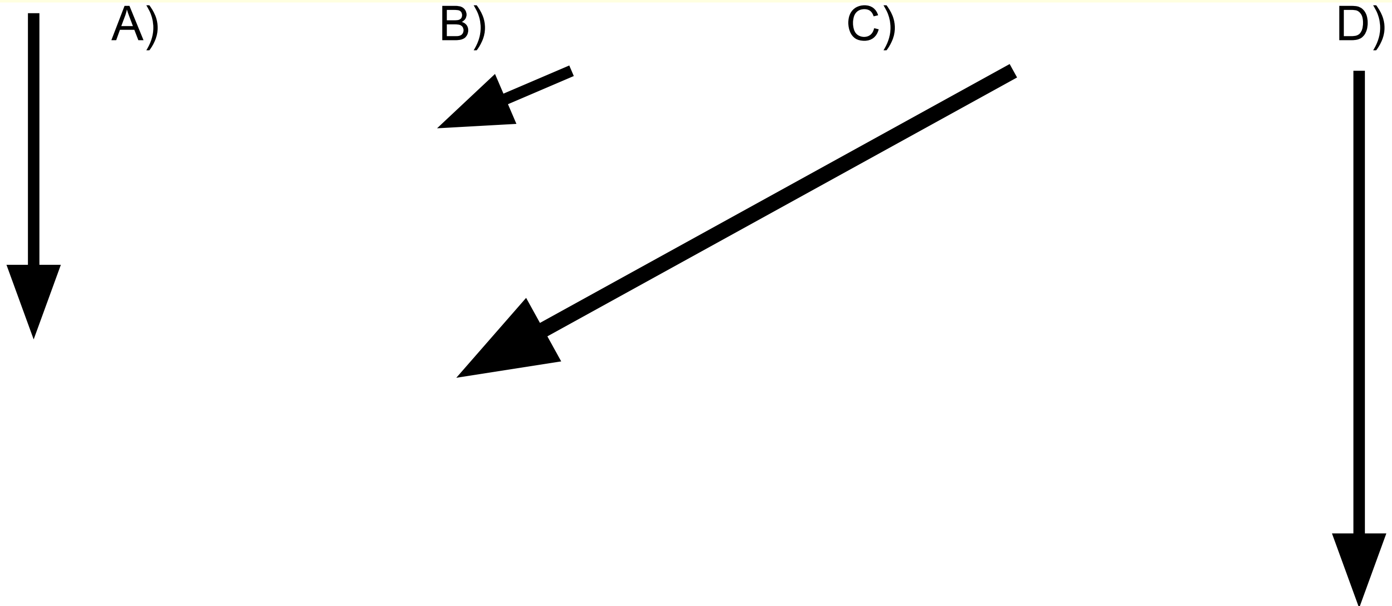
A 5 kg mass is acted upon by 4 forces: a 5 N force acting along +x, a 6 N force acting along +y, a 12 N force acting along -y, and a 13 N force acting along -x. What is the magnitude of the net acceleration of the mass?

A) 1 m/s^2
B) 2 m/s^2
C) 3 m/s^2
D) 4 m/s^2
E) NOTA

At t=0, a 2 kg mass has $|v|=6$ m/s, at -30^o wrt -y. At t=8 s, $|v|=4$ m/s along the +y-direction. Given that $\mathbf{F}_{net}=m\mathbf{a}_{net}$, and $\mathbf{a}=(\mathbf{v}_f-\mathbf{v}_i)/t$, estimate (graphical vector addition/subtraction) the net force $\mathbf{F}_{net}$ acting on the mass to be:

A) 2 N
B) 8 N
C) 14 N
D) 20 N
E) 32 N

A 2 kg mass is acted upon by a 30 N force acting in the negative y-direction and also a 20 N force acting at -60° wrt -x-axis. Which of the following best represent the final acceleration vector, if the magnitude of the first vector shown is 4 m/s^2?

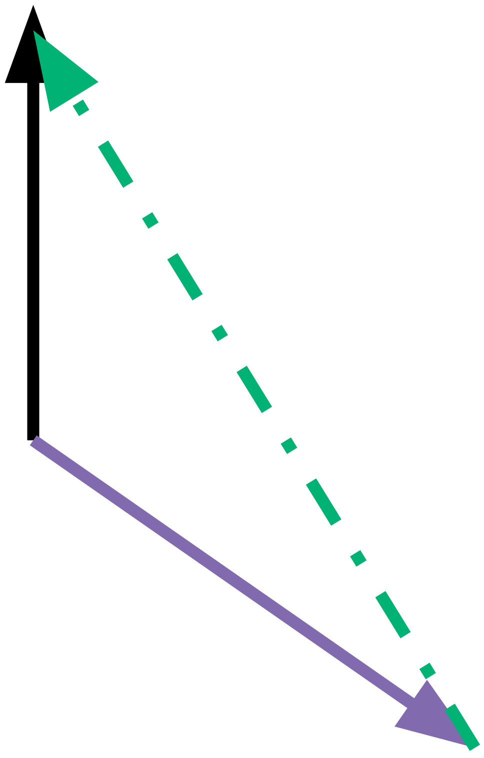


Two forces act on a 3 kg mass having |a|=4 m/s^2 in +y. If F_1 is 15N at -30^o wrt +x, graphically estimating F_2 gives a magnitude of:

A) 15 N B) 25 N C) 35 N D) 45 N

Two forces act on a 3 kg mass having $|a|=4\ m/s^2$ in +y. If F_1 is 15N at -30^o wrt +x, estimate F_2 graphically.

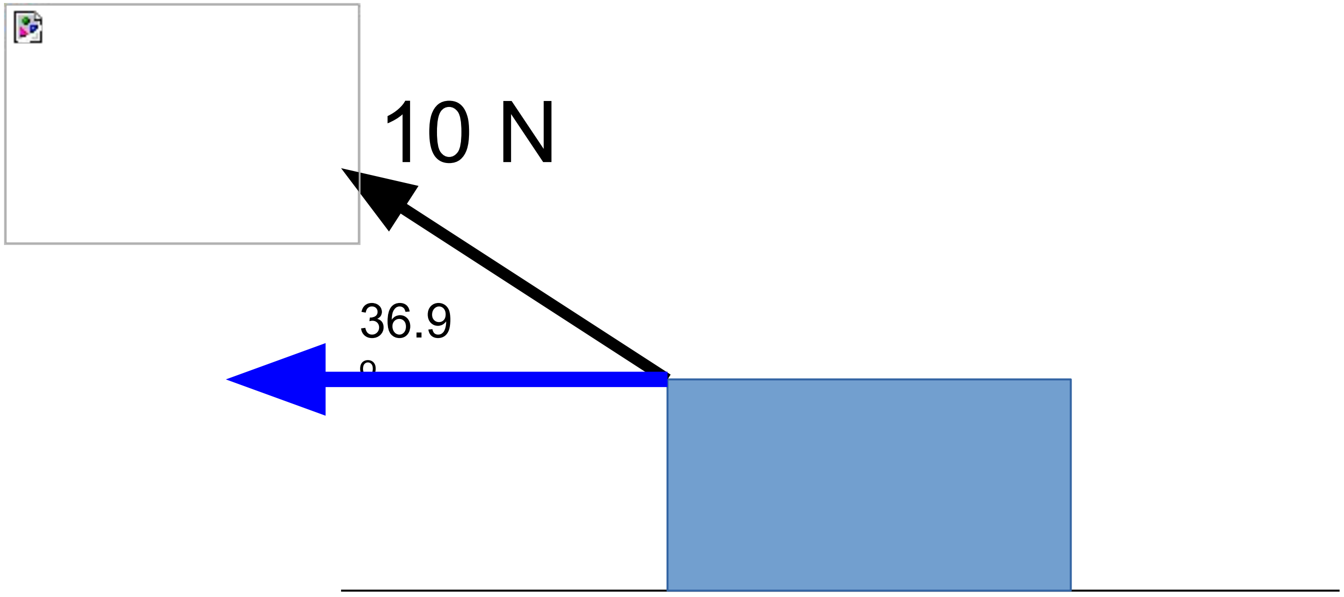
Soln: Use standard vector addition: **A+B=R.** In this case, we have **R=ma**, and also **A=F_1**, so find the vector **B** that you would add tip-to-tail to A to get **ma**. Pictorally:



Static vs. kinetic friction:
Latter for, e.g., two surfaces sliding against/over each other. Former for istantaneously at-rest (two boxes on top of one another; frictional force of a car on a track prior to sliding up/down the incline, etc.). Static: $F_{f,s} <= \mu_s N$; Kinetic: $F_K = \mu_K N$; since intermolecular forces have more time to interact when stationary:

$$\mu_K < \mu_s$$

Laika, the wonder dog, pulls a 4 kg box along a rough floor at a constant velocity of 2 m/s, as shown. The magnitude of the force of friction acting on the box is:



A) 4 N
B) 6 N
C) 8 N
D) 10 N
E) NOTA

Laika, the wonder dog, pulls a 4 kg box along a rough floor at a constant velocity of 2 m/s, as shown. The normal force acting on the box is:

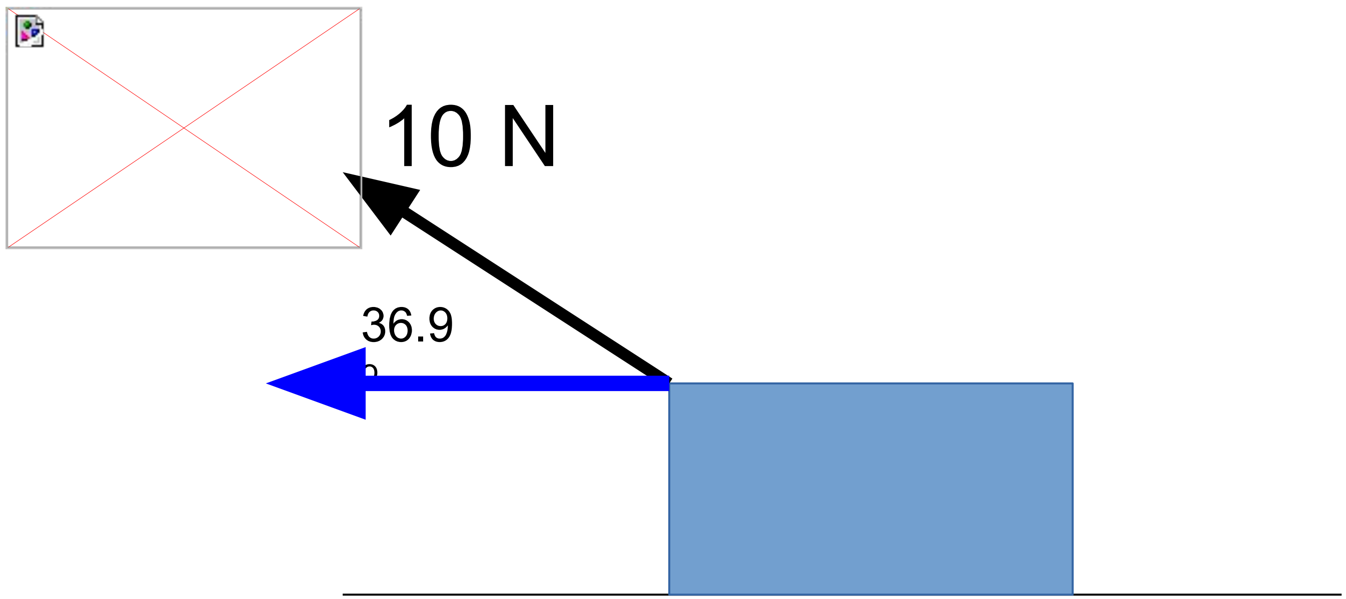
A) 39.2 N

B) 45.2 N

C) 33.2 N

D) 32.2 N

E) NOTA



A 2kg box is pushed by a 20 N force making an angle of 30° wrt -x. If μ_K=0.2, how far does the box move in 4 seconds?

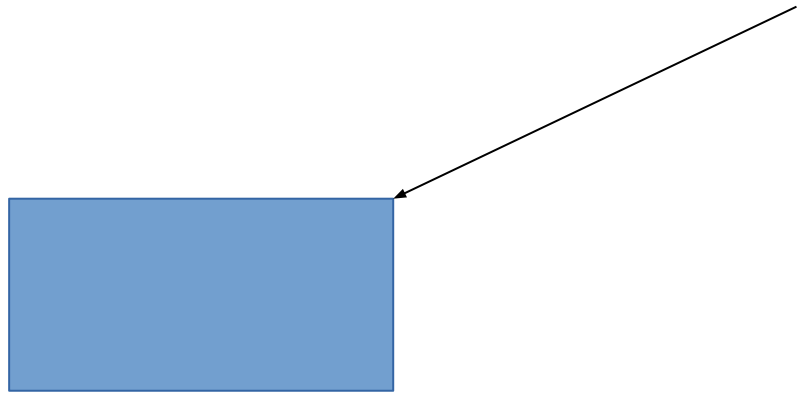
A) 45.6 m

B) 16.2 m

C) 104.4 m

D) 93.15 m

E) NOTA



A 4 kg elevator ascends with an acceleration of 2 m/s^2. What is the tension in the cable holding the elevator?

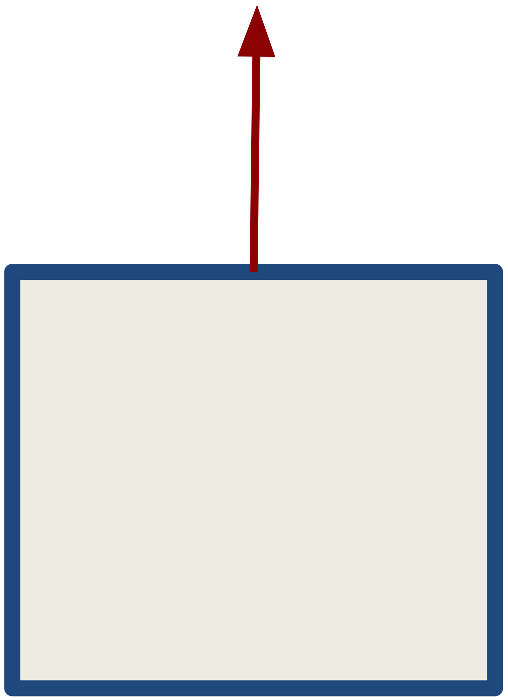
A) 8 N

B) 47.2 N

C) 31.2 N

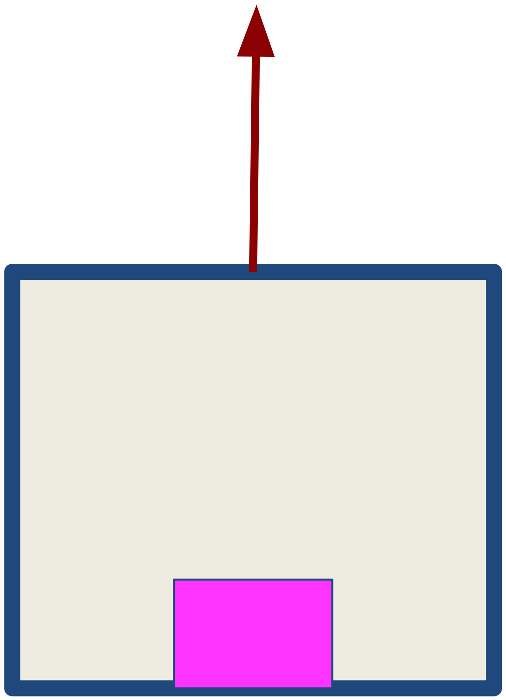
D) 39.2 N

E) NOTA



A 2 kg mass sits on the floor of an elevator accelerating/descending at 2 m/s^2. What is the normal force of the elevator on the mass?

A) 4 N
B) 19.6 N
C) 15.6 N
D) 23.6 N
E) NOTA



A 42.23 N force acts on the 2.887 kg mass, as a result of which the mass accelerates up along a rough incline shown with an acceleration of 1.732 m/s^2. The number of x’ vs. y’ force components acting on the mass is:

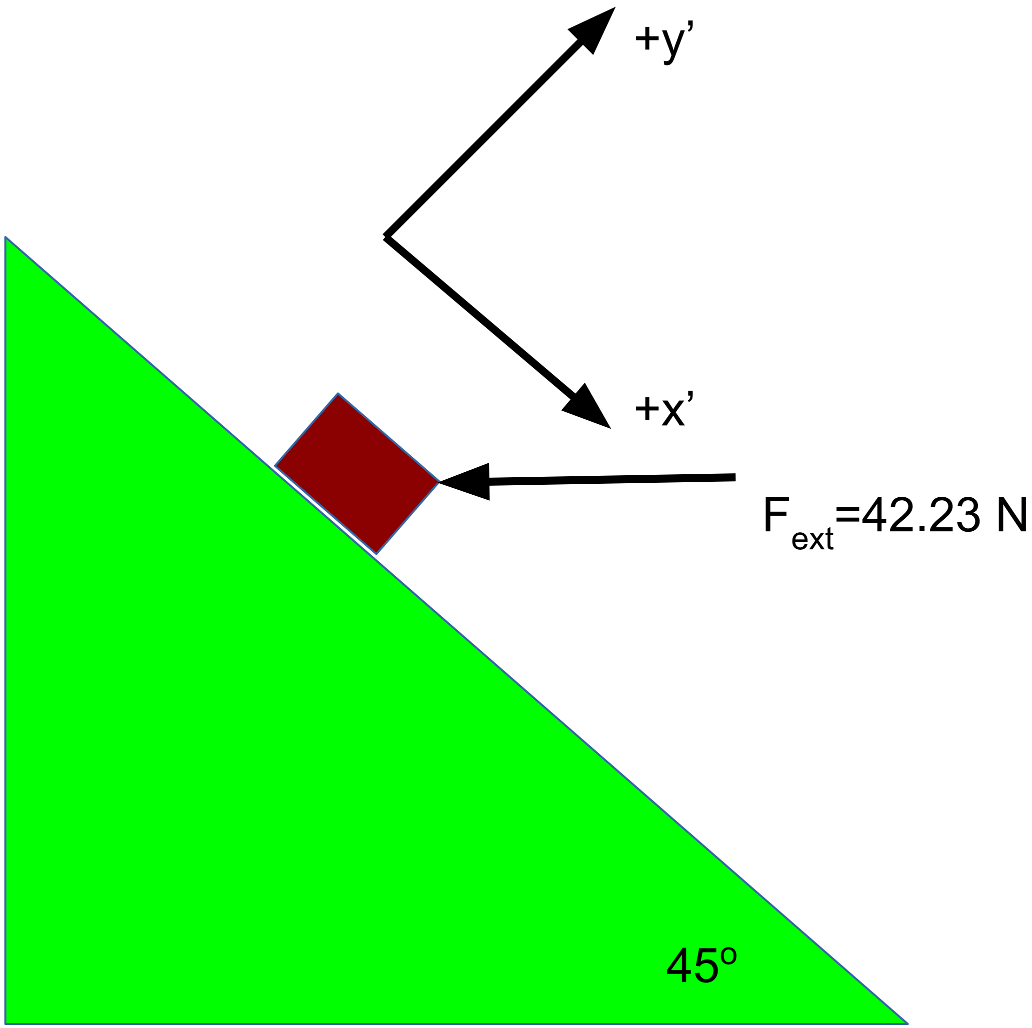
A) 3 in x’, 3 in y’

B) 3 in x’, 4 in y’

C) 4 in x’, 3 in y’

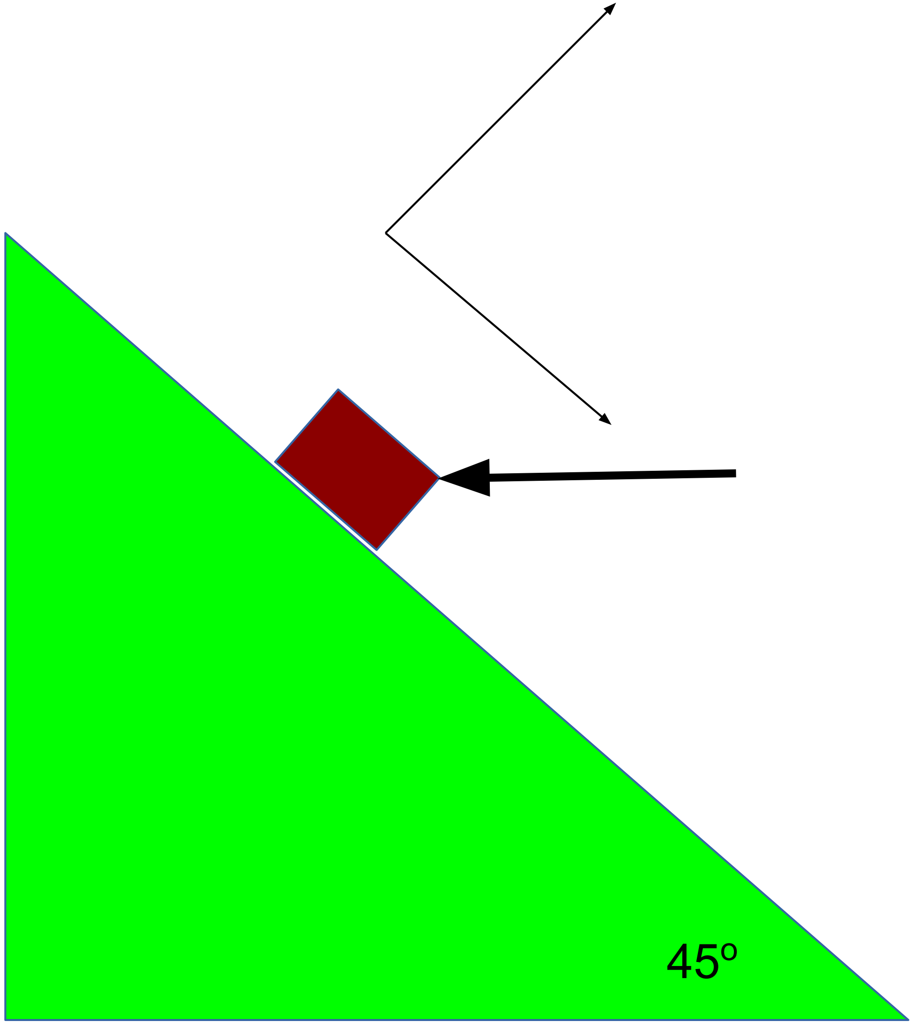
D) 4 in x’, 4 in y’

E) NOTA



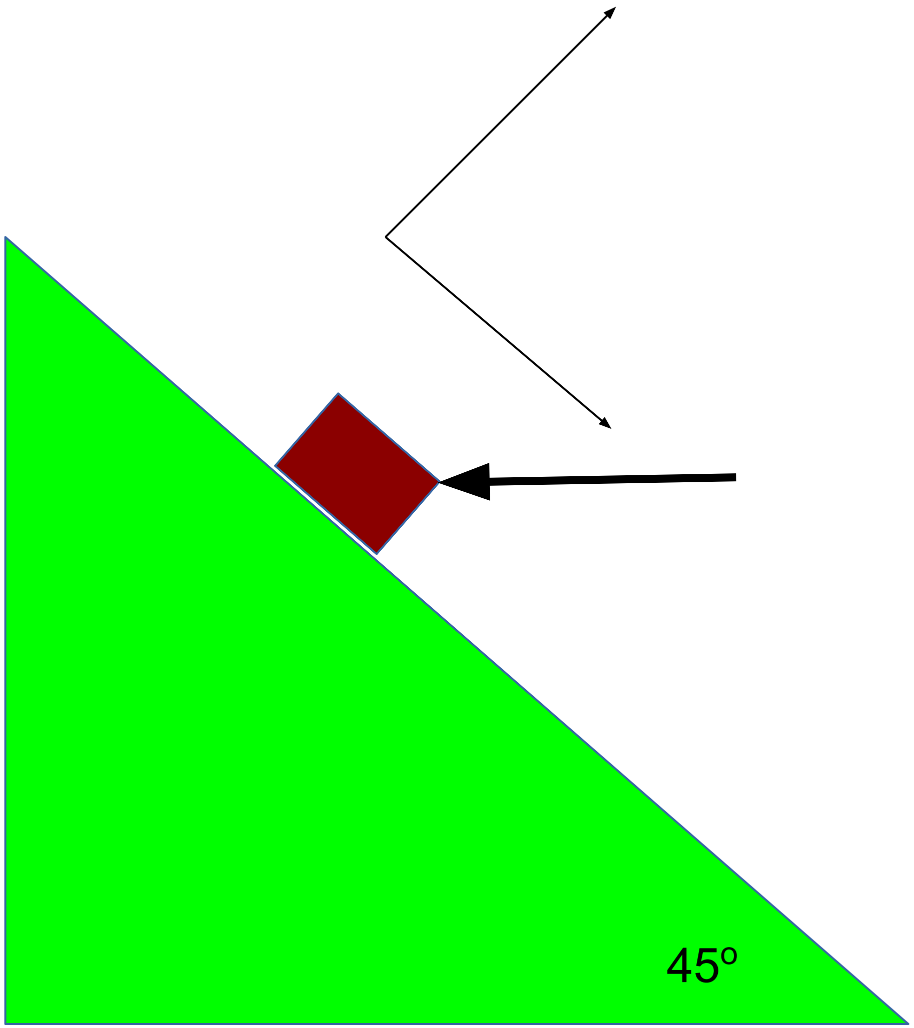
A 42.23 N force acts on the 2.887 kg mass shown, as a result of which the mass accelerates up along a rough incline with an acceleration of 1.732 m/s^2. The magnitude of the normal force of the incline on the mass is:

A) 30 N
B) 10 N
C) 50 N
D) 20 N
E) NOTA



The magnitude of the frictional force of the incline, and the value of μ_K is:

A) 5N, 0.1
B) 10N, 0.2
C) 15N, 0.3
D) 20N, 0.4
E) NOTA



A 10 kg mass is stationary on a rough 50° incline. From a force diagram, the frictional force is closest to:

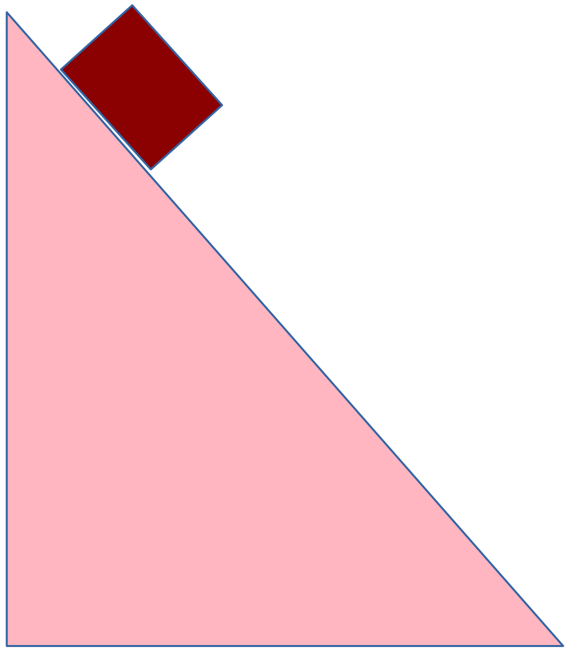
A) 15 N

B) 25 N

C) 35 N

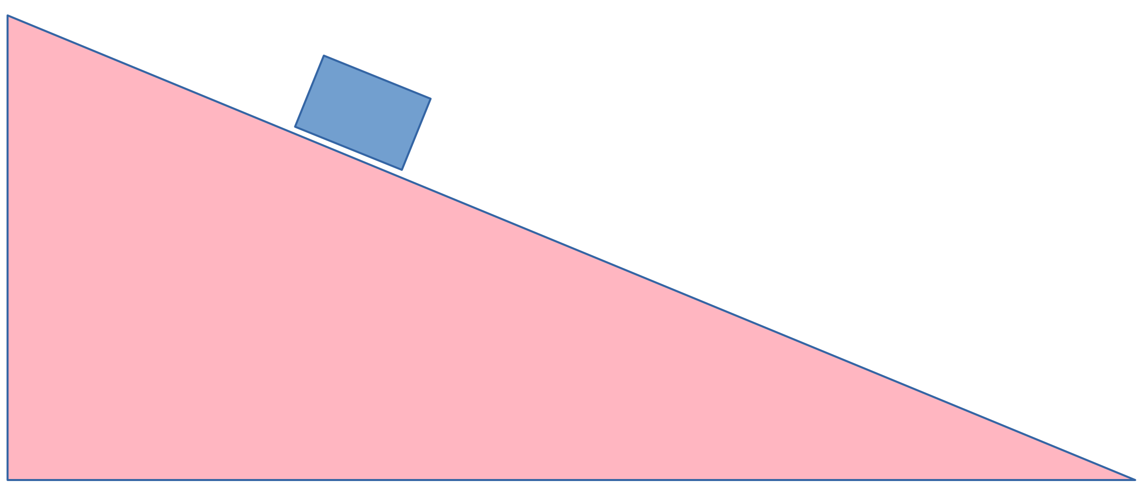
D) 45 N

E) 65 N



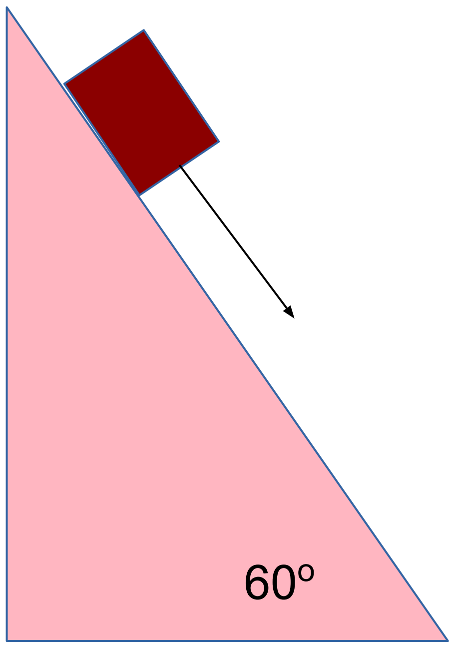
As the incline angle relative to the horizontal is decreased, which of the following decrease?

A) Normal force
B) Frictional force
C) Both A) and B)
D) Neither A) nor B)



A 4 kg mass accelerates at $|a|=10\ m/s^2$ down a frictionless 60^o incline. The pulling force (parallel to the incline) is closest to (estimate from a force diagram):

A) 5 N
B) 20 N
C) 35 N
D) 50 N



A 4 kg mass is being pulled, at $|a|=10\ m/s^2$ parallel to a 60^o incline with $\mu_k=0.5$. The pulling force is closest to (check graphically with a force diagram):

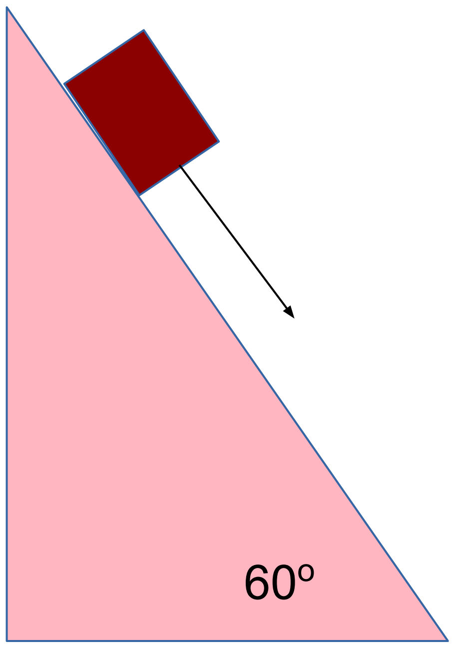
A) 15 N

B) 25 N

C) 35 N

D) 45 N

E) 55 N



A 4 kg mass slides down a rough 30° incline with an acceleration of 2 m/s^2. From graphical vector addition, the magnitude of the normal and frictional forces are approximately (respectively):

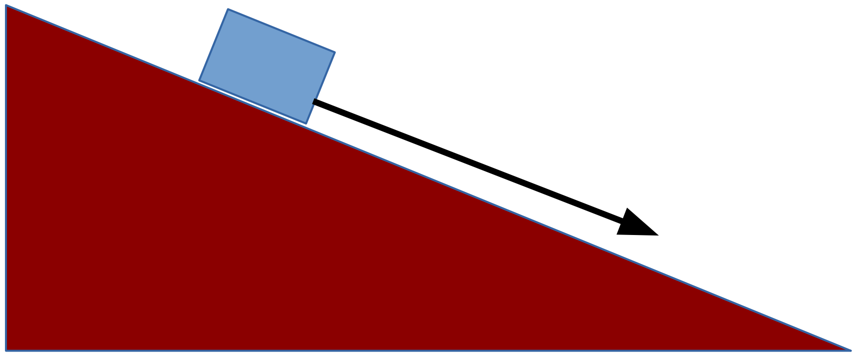
A) 39.2 N, 39.2 N

B) 39.2 N, 11.6 N

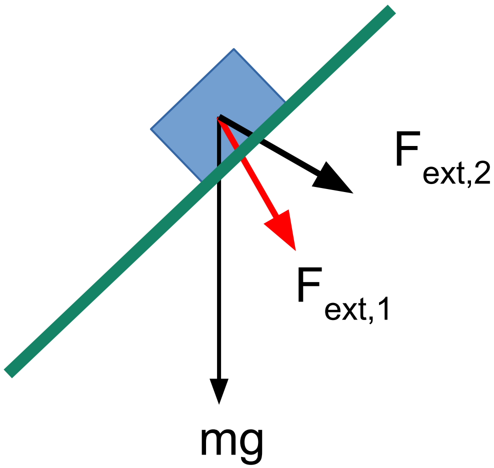
C) 11.6 N, 39.2 N

D) 34 N, 11.6 N

E) NOTA



In addition to gravity and the normal force, two external forces act on a 4 kg mass on an incline. You could infer that the normal force is about



A) 20 N

B) 40 N

C) 70 N

D) 120 N

Based on the force diagram, the mass likely:
A) is stationary
B) slides down the incline
C) slides up the incline

A 2.04 kg mass, falling in the Earth's gravitational field, has $\mathbf{a}_{net}$=4.9 m/s^2 (-y). In addition to gravity, two forces are in contact with the mass; the first is 40 N at -60^0 wrt +y. The 2nd contact force magnitude is about

A) 15 N

B) 35 N

C) 55 N

D) 75 N

E) 95 N

A 4 kg mass is on a rough inclined plane making an angle of 36.9° wrt horizontal, and sliding down the incline with |a|=2 m/s^2. What is the magnitude of Normal force of the incline acting on the mass?

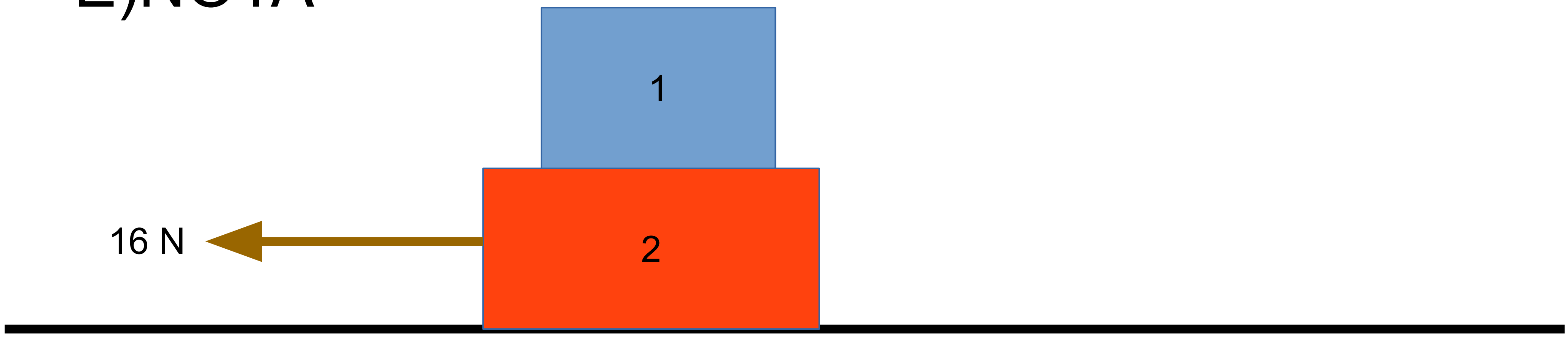
A) 39.2 N
B) 7.52 N
C) 31.4 N
D) 16 N
E) NOTA

A 4 kg mass is on an inclined plane making an angle of 36.9^o wrt horizontal, and sliding down the incline with $|a|=2$ m/s^2. What is the magnitude of the frictional force of the incline acting on m?

A) 39.2 N
B) 7.52 N
C) 31.4 N
D) 15.5 N
E) NOTA

2 masses (m_{top}=2 kg; m_{bottom}=4 kg) are being pulled over a rough surface with a force of 16 N, as shown; they move together with an acceleration of magnitude 2 m/s^2

A) The number of forces acting on the top and bottom mass, respectively, is: A) 3,4 B) 4,3 C) 4,4 D) 3,6 E)NOTA



In the previous problem, the frictional force acting on the top box must be:

A) -12 N

B) -4 N

C) -16 N

D) -48 N

E) NOTA

In the same problem, the frictional force acting between the floor and the bottom box is, in magnitude:

A) 12 N

B) 4 N

C) 16 N

D) 8 N

E) NOTA

In the same problem, the coefficient of kinetic friction between the floor and the bottom box, μ_k=

A) 0.1

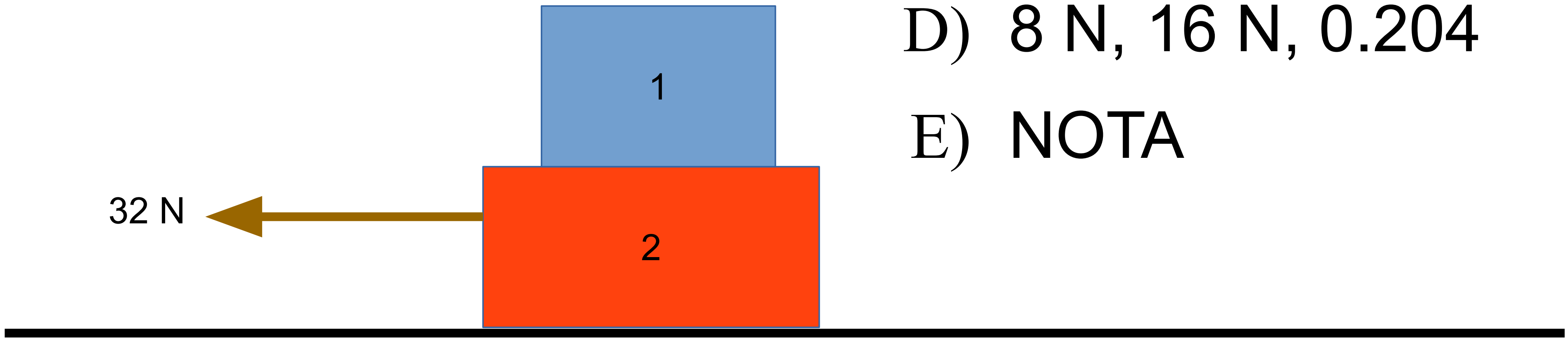
B) 0.0684

C) 0.1378

D) 0.4

E) NOTA

2 masses (m_{top}=4 kg; m_{bottom}=4 kg) are being pulled over a rough surface with a force of 32 N, as shown; they move together with an acceleration of magnitude 2 m/s^2. $F_{friction,\ 2\text{-on-}1}$, $F_{friction,\ floor\text{-on-}2}$, and the coefficient of kinetic friction b/w floor and box 2 are:

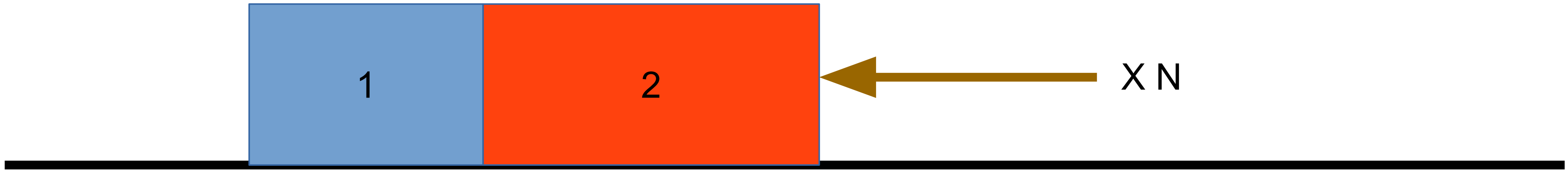


A) 16 N, 16 N, 0.1
B) 8 N, 4 N, 0.05
C) 4 N, 4 N, 0.068
D) 8 N, 16 N, 0.204
E) NOTA

2 masses (m_1=2 kg; m_2=4 kg) are being pulled over a rough surface (μ_k=0.1) as shown; they move together with an acceleration of magnitude 3 m/s^2

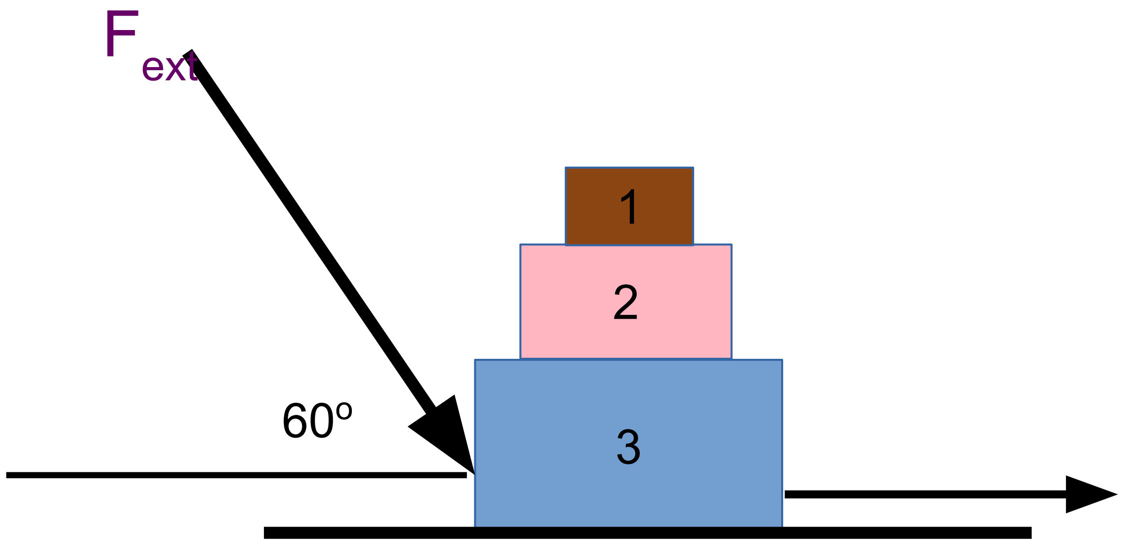
A) What is the magnitude of:

i) $F_{normal,\ 2\text{-}on\text{-}1}$, ii) $F_{friction,\ floor\text{-}on\text{-}2}$, iii) the external force



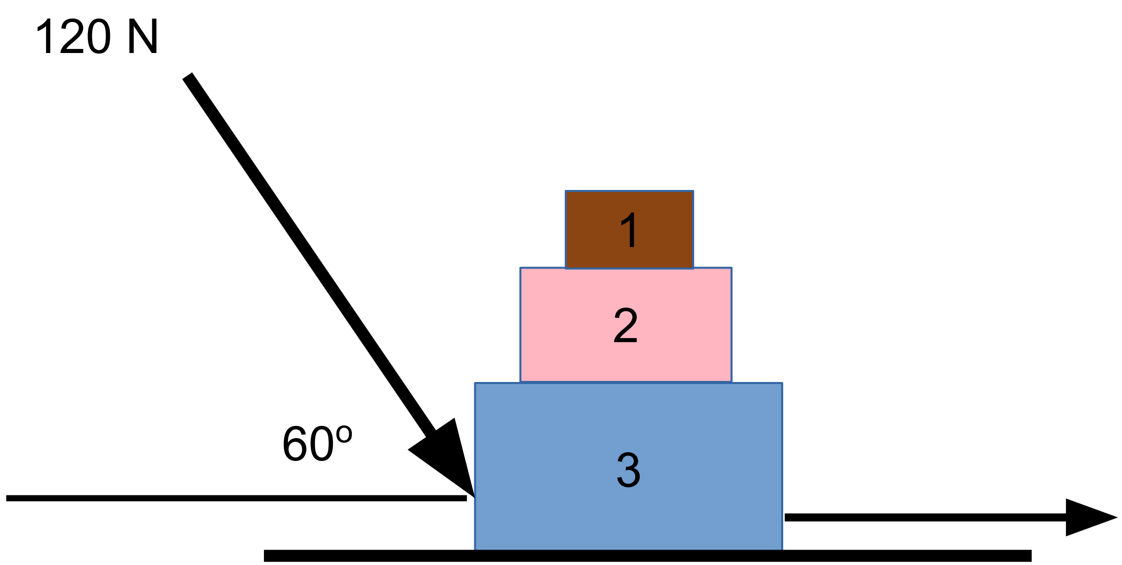
A) 4N B) 8N C) 12N D) 16N E) 24 N

Three boxes (m_{top}=2 kg; m_{middle}=4 kg; m_{bottom}=6 kg) are stacked vertically on a rough floor, with F_{ext} on the bottom box, and moving uniformly to the right. The number of forces acting on the 3 boxes (top→bottom) is:



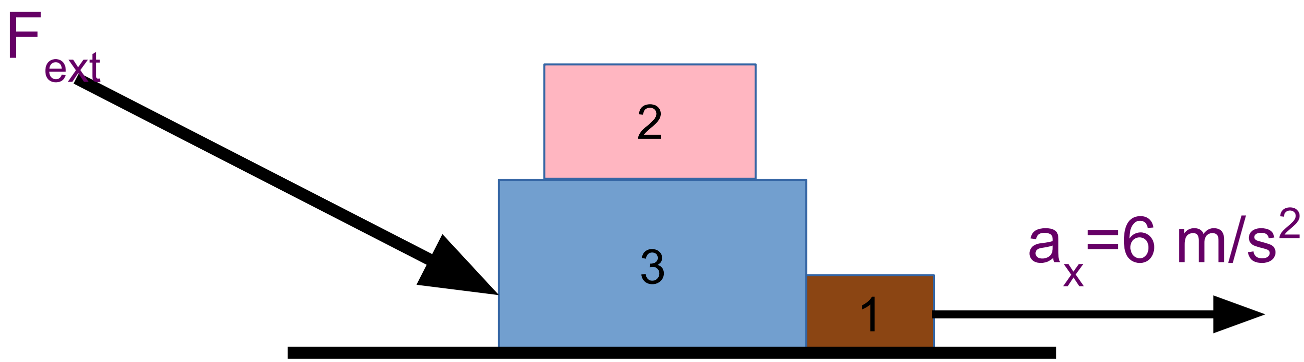
A) 3,6,6 B) 4,4,4 C) 6,6,6 D) 3,5,6 E) NOTA

Three boxes (m_{top}=2 kg; m_{middle}=4 kg; m_{bottom}=6 kg) are stacked vertically on a rough floor, with F_{ext} on the bottom box, and moving uniformly to the right with a_x=6 m/s^2. The normal force of the floor on box 3 is:



A) 58.8 N B) 117.6 N C) 221.5 N D) 103.9 N E) NOTA

Three boxes (m_1=2 kg; m_2=4 kg; m_3=6 kg) are stacked on a rough floor, with an unknown F_{ext} on box 3, and all moving uniformly to the right. The number of forces with components in the y-direction acting on the three masses is, respectively:



A) 2,3,4

B) 2,1,3

C) 2,2,4

D) 2,2,3

E) NOTA

Three boxes (m_1=2 kg; m_2=4 kg; m_3=6 kg) are stacked on a rough floor, with an unknown F_{ext} on box 3, and all moving uniformly to the right. The number of forces with components in the x-direction acting on the three masses is, respectively:

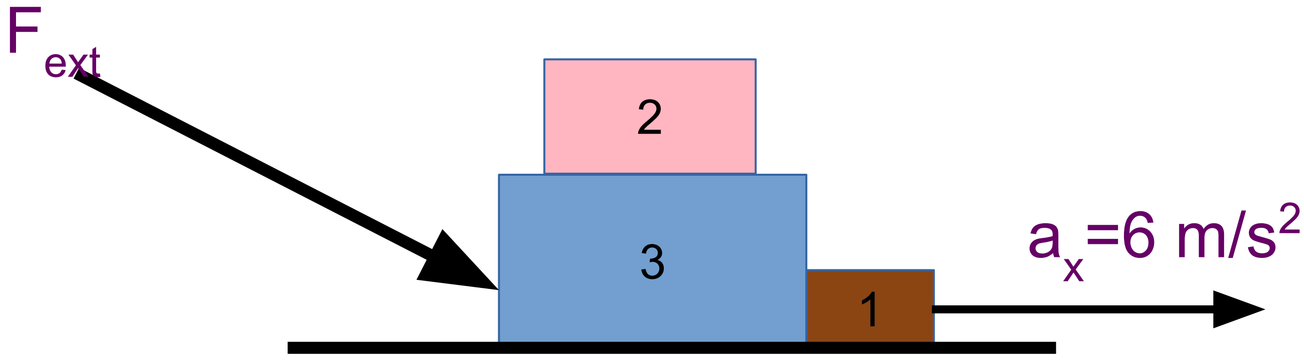
A) 2,3,4

B) 2,1,3

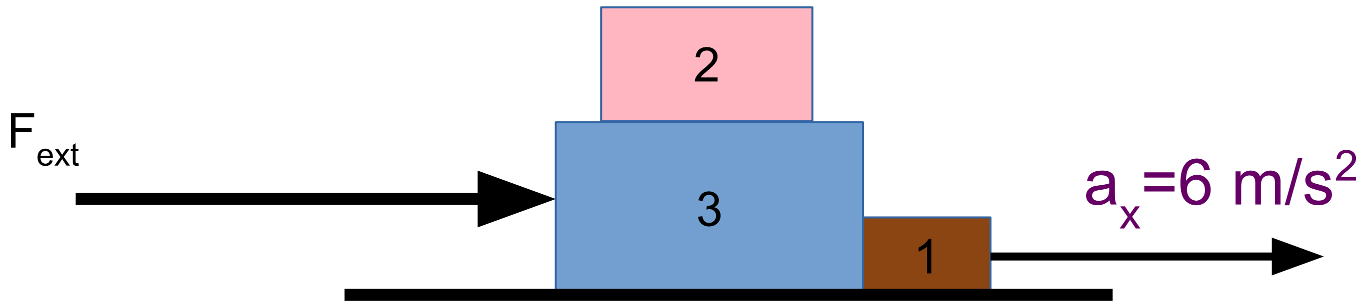
C) 2,1,4

D) 2,2,3

E) NOTA



Three boxes (m_1=2 kg; m_2=4 kg; m_3=6 kg) are stacked on a rough floor with μ_K=0.2, with F_{ext} on box 3, and all moving uniformly to the right. $N_{3\ on\ 1}$ is:



A) 15.92 N

B) 12 N

C) 3.92 N

D) 9.08 N

E) NOTA

Three boxes (m_1=2 kg; m_2=4 kg; m_3=6 kg) are stacked on a rough floor with μ_K=0.2, with F_{ext} on box 3, and all moving uniformly to the right. The unknown external force is:

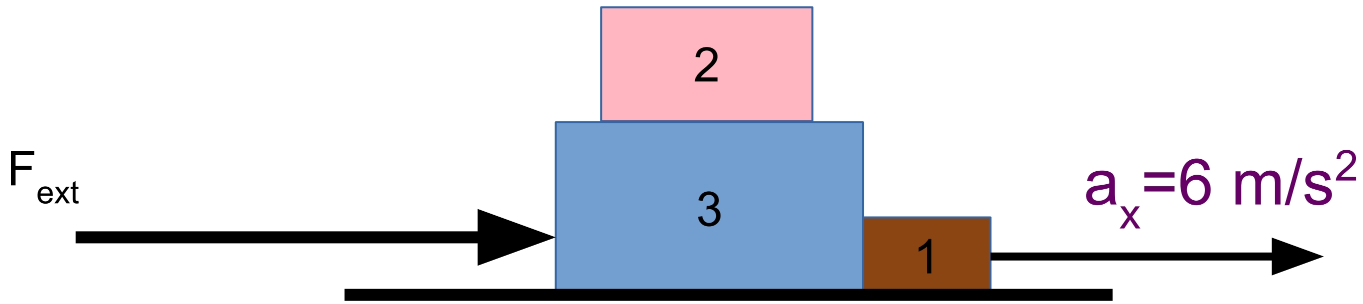
A) 15.92 N

B) 95.5 N

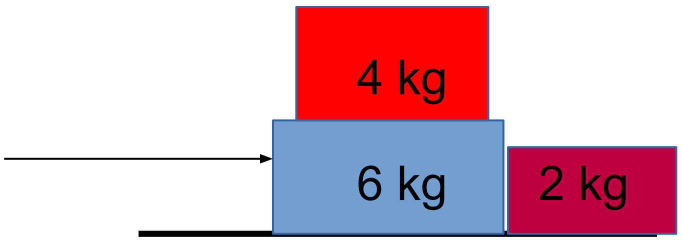
C) 49.72 N

D) 71.52 N

E) NOTA



What is the force b/w the 6 and 2 kg boxes, assuming all three boxes accelerate uniformly; kinetic friction coefficient on the floor=0.25



$\mu_K=0.25$

Laika, the wonder dog, pushes against box 3; the 3 boxes subsequently accelerate to the left on a frictionless surface with acceleration of magnitude 2 m/s^2. The magnitudes $F_{2\ on\ 1}$, $F_{3\ on\ 2}$, and F_{Laika} are, respectively:

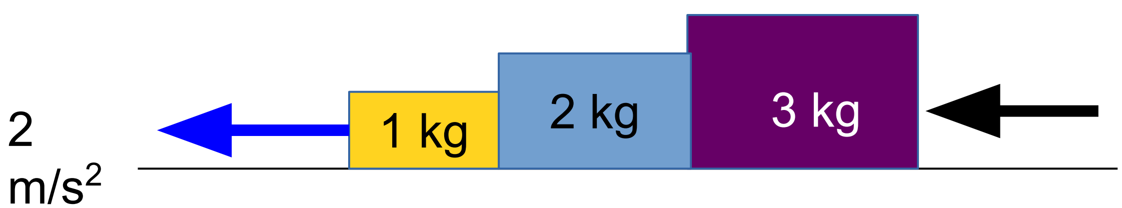
A) 6 N, 6 N, 6 N

B) 2 N, 12 N, 12 N

C) 2 N, 6 N, 12 N

D) 12 N, 6 N, 2 N

E) NOTA



Comment on previous problem – you could have guessed at the answer, by imagining that Laika just “sees” a total of 6 kg; that box 3 “sees” 3 kg to its left, and box 2 “sees” 1 kg to its left, etc.

Laika, the wonder dog, pushes against box 3 with a force of 18 N; the 3 boxes subsequently accelerate to the left on a rough surface having m_k=0.2. After two seconds, the boxes have moved

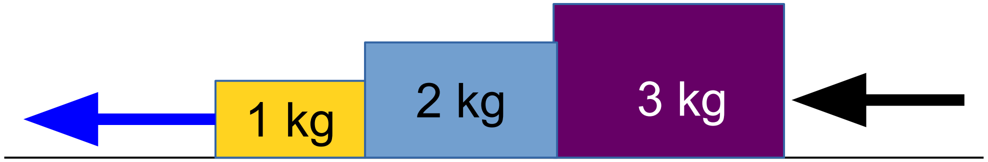
A) 5.34 m

B) 2.67 m

C) 11.11 m

D) 2.07 m

E) NOTA



Laika, the wonder dog, pushes against box 3 with a force of 48 N; the boxes accelerate to the left at 2 m/s^2. The coefficient of kinetic friction between the floor and the boxes is:

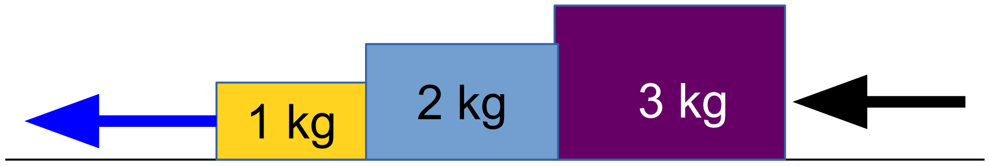
A) 0.21

B) 0.41

C) 0.61

D) 0.81

E) NOTA



A fourth box with a rough bottom is now stacked on top of box 2. As they accelerate to the left, the total number of forces acting in the +x direction, on box 2 is:

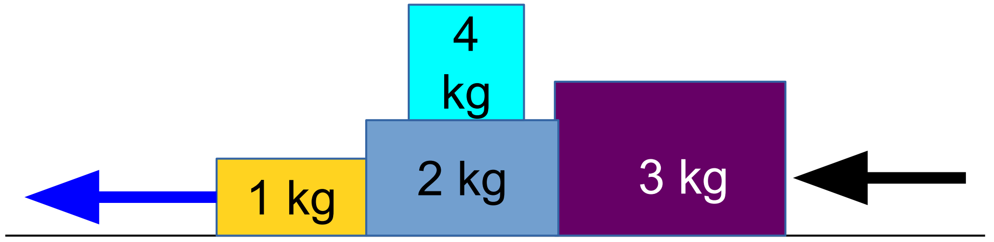
A) 3

B) 4

C) 5

D) 6

E) 7



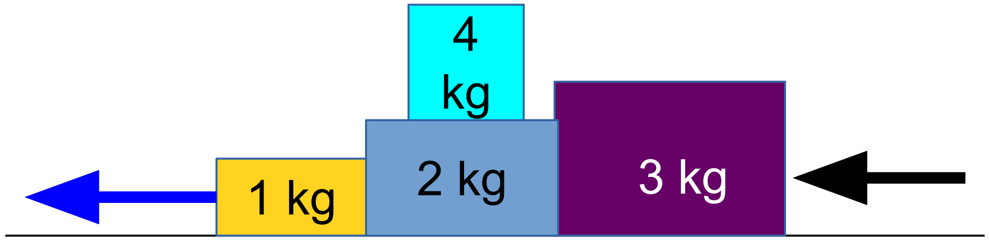
A fourth box is now stacked on top of box 2; the coefficient of static friction is 0.2. As Laika pushes harder, and the boxes continue to accelerate to the left, which is true?

A) $N_{2\ on\ 4}$ increases

B) $F_{friction,\ 2\ on\ 4}$ increases

C) Both of the above are true

D) Neither of the above are true



A 12 N force is applied to the 2 kg mass, and a 6 N force applied to the 1 kg mass, as shown, on a frictionless surface. $F_{2kg\ on\ 1kg}$=

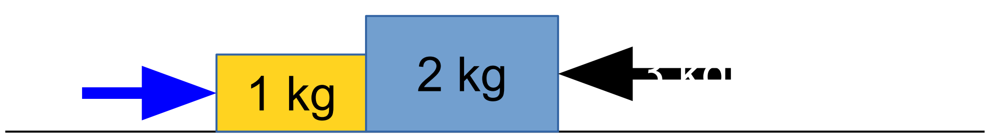
A) 2 N

B) 4 N

C) 6 N

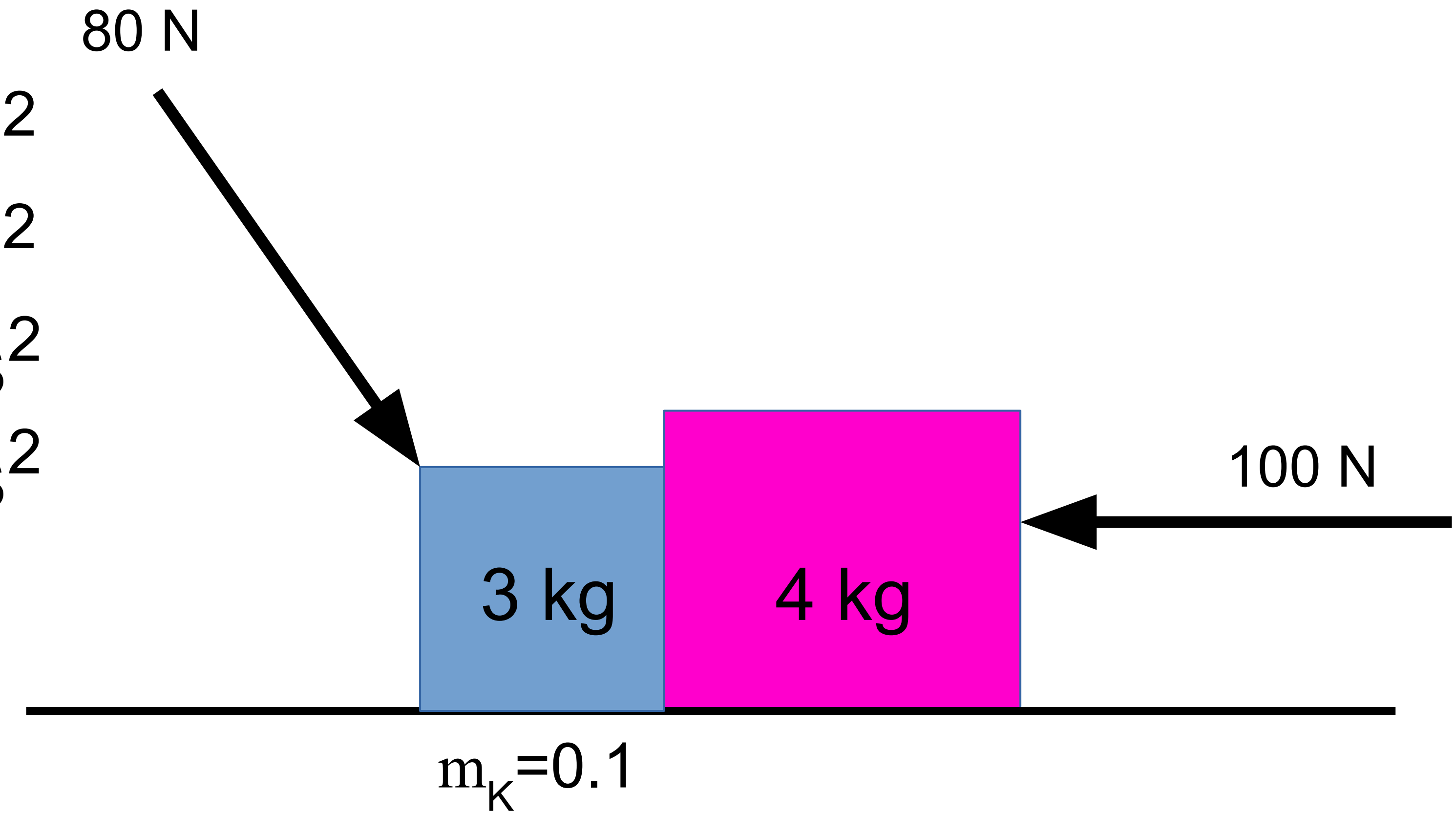
D) 8 N

E) NOTA



If the angle that the 80N force makes with the -x axis is -60°, then $F_{x,ext,net}$ and the x-acceleration of the two masses are:

A) 2.2 m/s^2
B) 4.4 m/s^2
C) 5.5 m/s^2
D) 6.6 m/s^2
E) NOTA



A 2 kg mass sits on top of a 3 kg mass, which itself is on the floor of an elevator descending at 9.8 m/s^2. What is the normal force of the floor on the 3 kg mass?

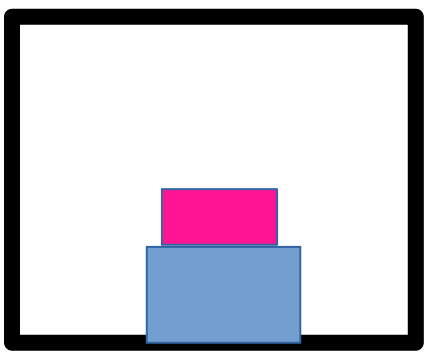
A) 19.6 N

B) 29.4 N

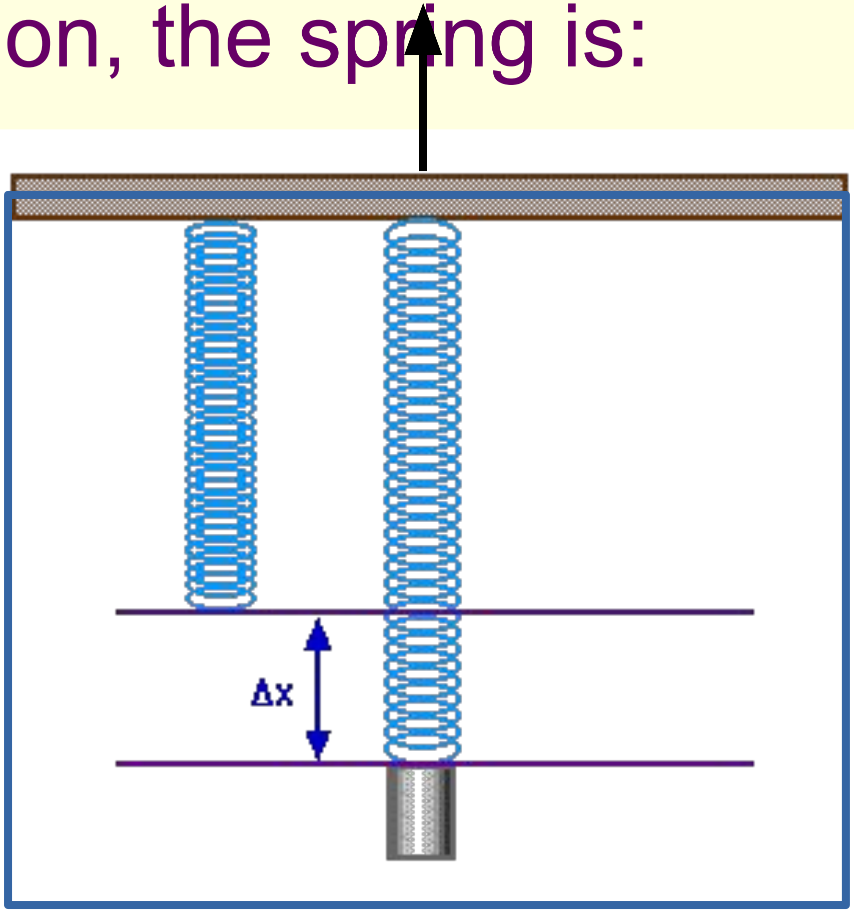
C) 49 N

D) 0 N

E) NOTA



A 2 kg mass is suspended by a spring with spring constant k=100 N/m, hanging from the ceiling of an elevator. Now the elevator begins to move upwards with $|a|=5\ m/s^2$. Relative to its no-mass configuration, the spring is:



A) Extended by ~30 cm

B) Compressed by ~30 cm

C) Extended by ~10 cm

D) Compressed by 1 cm

E) NOTA

Subtlety here!

A) Once the mass is attached to the spring inside the elevator, the spring assumes a new equilibrium position (stretched), and will, if perturbed, oscillate around this new position.

B) However, if the elevator begins accelerating up/down, compression/extension of the spring is calculated relative to the ORIGINAL equilibrium position (spring length if there were no mass on it) Since $ma=mg+k\Delta x$, consider cases:

- $a=0$; force of spring +y; $\Delta x=mg/k$ extension relative to no-mass length
- $a=g$ (i.e., elevator descending), $\Delta x=0$ (spring as long as it would be without the mass hanging from it), i.e., spring is compressed relative to $a=0$ case
- elevator ascending: $\Delta x=mg/k$ extension relative to no-mass length

A 2 kg mass is suspended by a spring with spring constant k=100 N/m, hanging from the ceiling of an elevator moving downwards with $|a|=9.8\ m/s^2$. Relative to its original position, the spring is: (try graphical addition to solve this problem)

A) Extended by 30 cm

B) Compressed by 30 cm

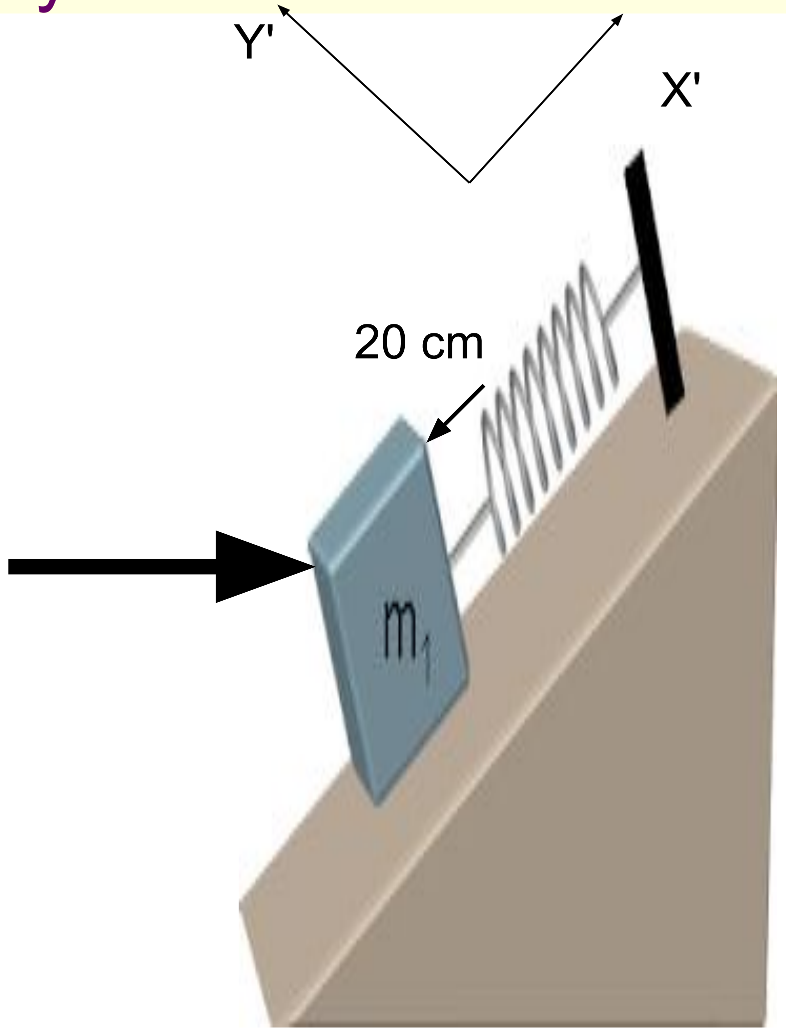
C) Extended by 10 cm

D) Compressed by cm

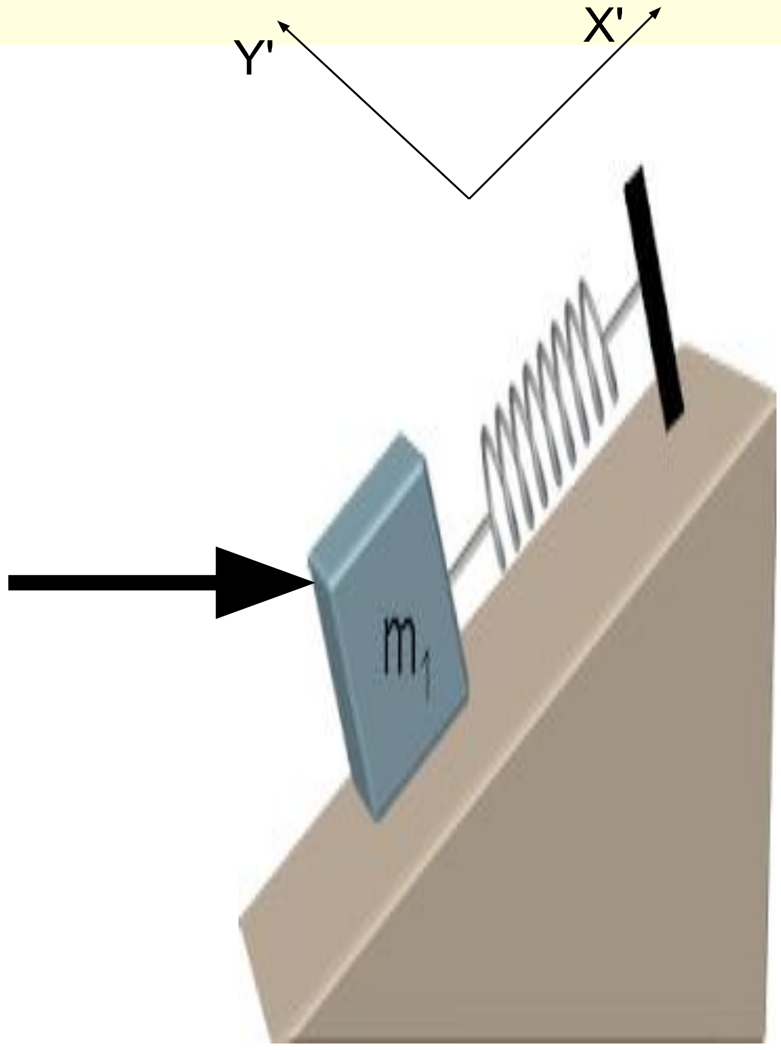
E) NOTA

A 6 kg mass, connected by a spring extended by 20 cm, sits on a 53.1°-angle plane with μ_s=0.2; an additional 10 N horizontal force also acts to prevent the mass from sliding DOWN the incline. The number of forces acting on the mass in the (rotated) x' and y' directions are:

A) 2 in x', 4 in y'
B) 2 in x', 3 in y'
C) 3 in x', 1 in y'
D) 3 in x', 2 in y'
E) NOTA



A 6 kg mass, connected by a spring extended by 20 cm, sits on a 53.1°-angle plane with μ_s=0.2; an additional 10 N horizontal force also acts to keep the mass from sliding down the incline. The magnitude of the Normal force is:



A) 35.28 N

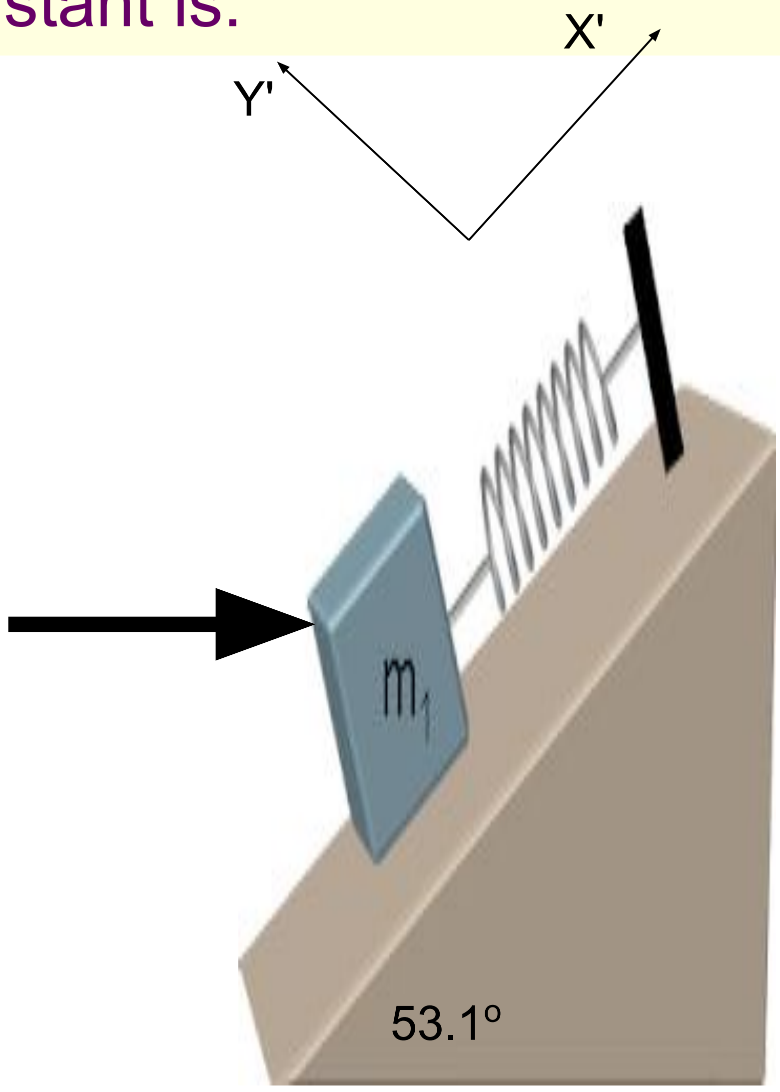
B) 43.28 N

C) 45.28 N

D) 41.28 N

E) NOTA

A 6 kg mass, connected by a spring extended by 20 cm, sits on a 53.1°-angle plane with μ_s=0.2; an additional 10 N horizontal force is the minimum needed to hold the mass in place. Assuming the static frictional force is a maximum, then the value of the spring constant is:



A) 161.92 N/m

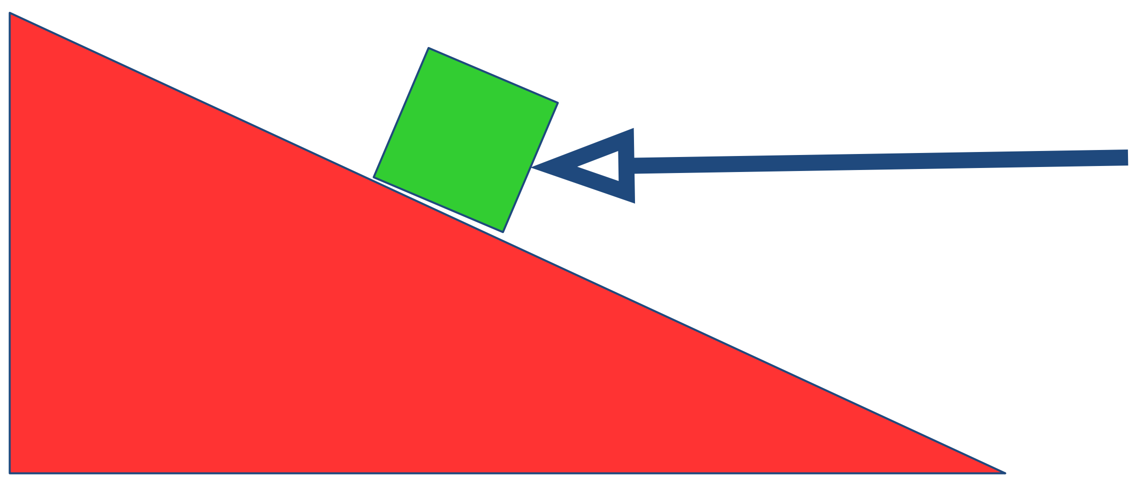
B) 232.4 N/m

C) 32.88 N/m

D) 16.56 N/m

E) NOTA

Given a 10 kg mass on the frictionless incline shown acted on by a horizontal force. Estimate the magnitude of the external force such that the acceleration up the incline has magnitude 5 m/s^2 What is the value of the normal force, in that case?



A 64-kg Calder hangs between two walls. Wire 1 makes an angle of -78.46^o wrt +y; the other makes an angle of -60^o wrt -x. The equations you would need to solve for the tension in the two wires, in terms of sines and cosines, are:

A) $T_1\sin(78.46)-T_2\cos(60)-(64)*9.8=0$; $T_1\cos(78.46)+T_2\sin(60)=0$;

B) $T_1\sin(78.46)+T_2\cos(60)-(64)*9.8=0$; $-T_1\cos(78.46)+T_2\sin(60)=0$;

C) $T_1\cos(78.46)+T_2\sin(60)-(64)*9.8=0$; $-T_1\cos(78.46)+T_2\sin(60)=0$;

D) $T_1\cos(78.46)+T_2\sin(60)-(64)*9.8=0$; $T_1\sin(78.46)-T_2\cos(60)=0$;

E) NOTA

A 50 kg Calder hangs on two cables, between two walls as shown. The tension in the two cables (left, right) is closest to:

A) 245 N, 245 N

B) 150 N, 350 N

C) 350 N, 150 N

D) 250 N, 450 N

E) 450 N, 250 N

A 1.02 kg cubist cube hangs as shown. By solving two equations in two unknowns, the value of the tensions T_1 and T_2 are:

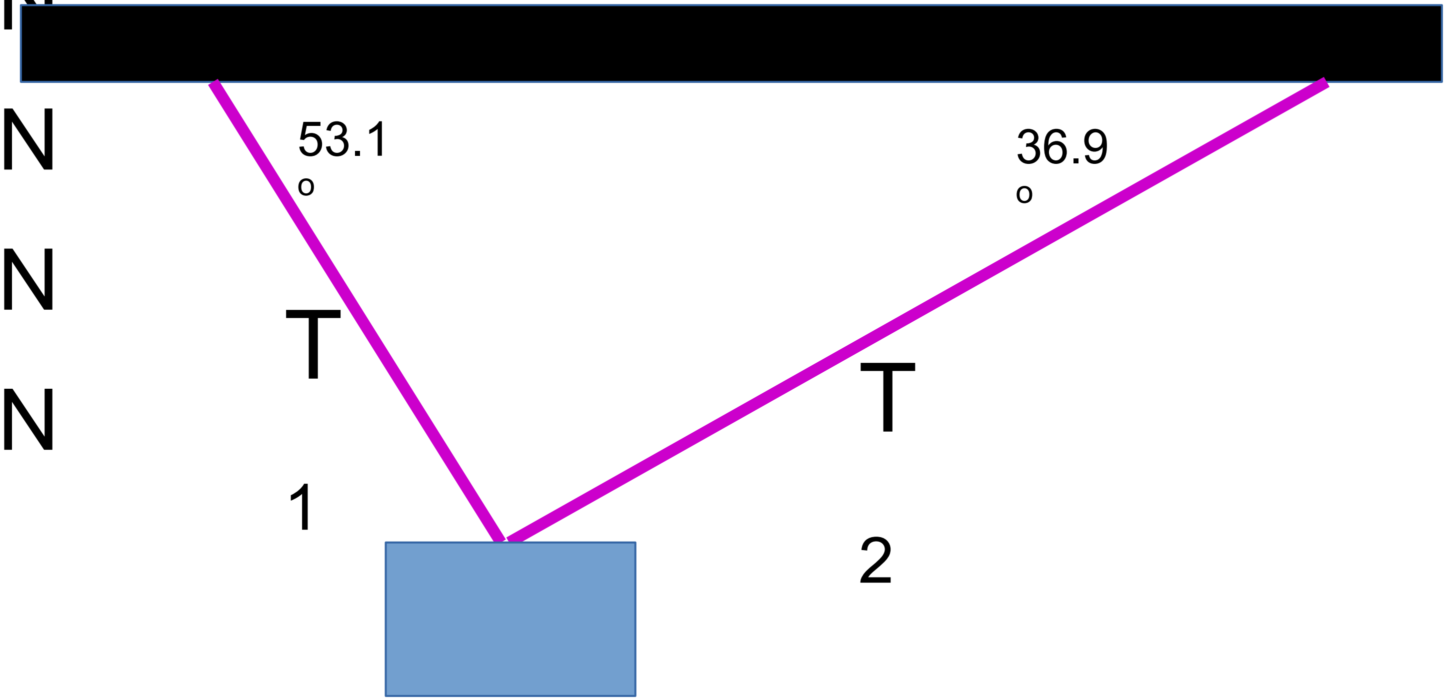
A) T_1=5 N; T_2=5 N

B) T_1=6 N; T_2=4 N

C) T_1=8 N; T_2=6 N

D) T_1=6 N; T_2=8 N

E) NOTA



Two masses are connected by a wire; one mass (m_1=2 kg) slides horizontally on a frictionless table while m_2 falls vertically. If they fall uniformly at 7.8 m/s^2, what is the value of m_2?

A) 4 kg

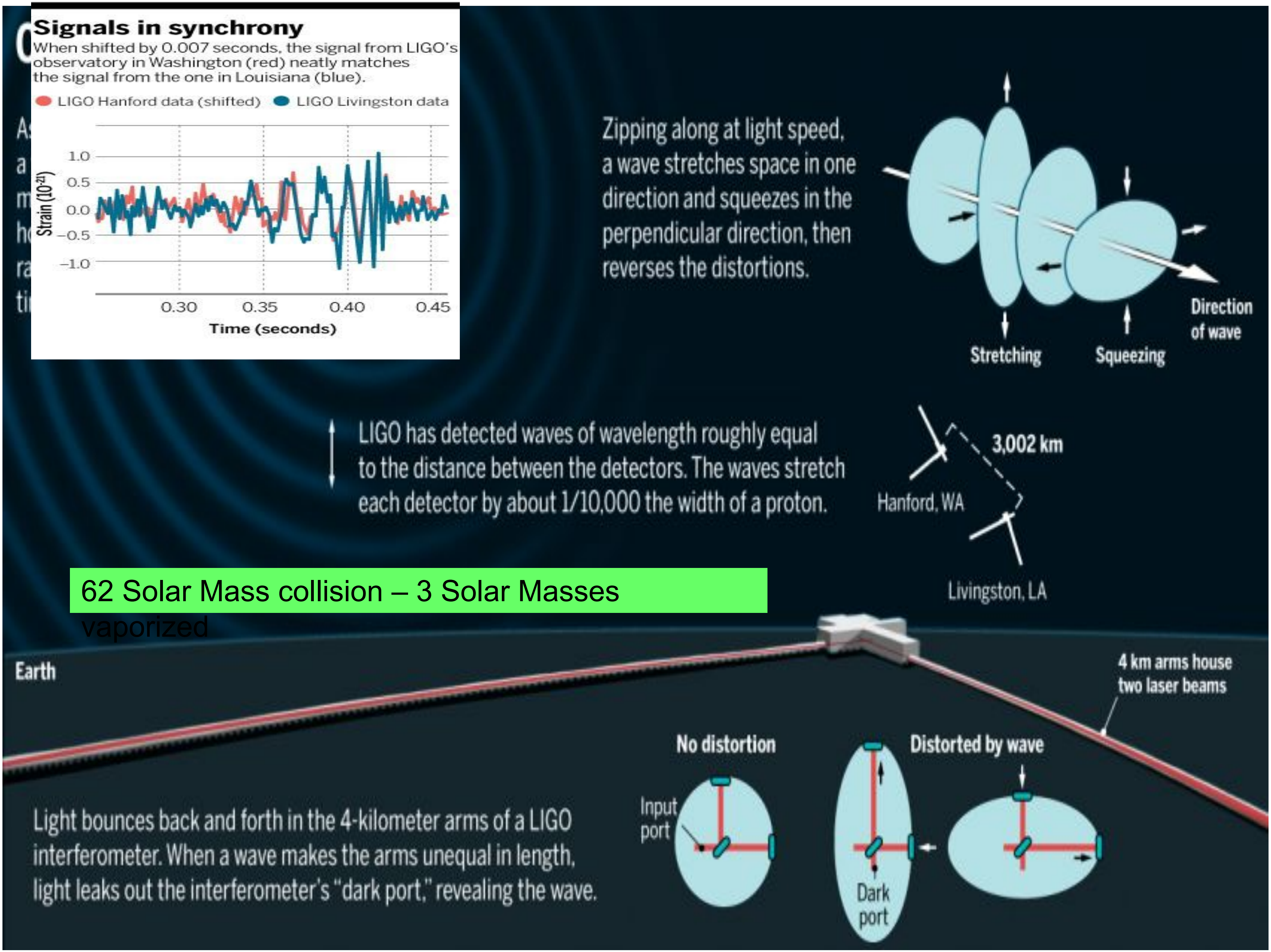
B) 6 kg

C) 7.8 kg

D) 9.8 kg

E) NOTA

Ch. 6 – covering 6.1-6.4
Note: will defer discussion of gravitation until end of semester, to segueue directly into electricity



62 Solar Mass collision – 3 Solar Masses vaporized

The Galactique Acid 7” EP spins on a turntable at an initial angular velocity $\omega_i = 2$ rad/s, clockwise. Determine the total angular displacement if a counter-clockwise angular acceleration of magnitude 4 rad/s^2 is applied for two seconds.

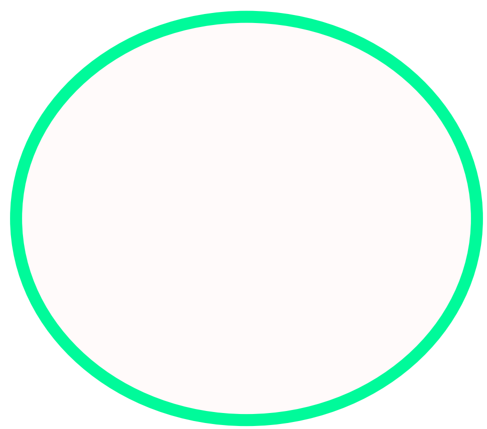
A) 0 rad

B) -2 rad

C) +4 rad

D) -4 rad

E) NOTA



Suppose the EP is spinning with $|\omega_i|=4$ rads/s clockwise. Determine the total $\Delta\theta$ if a counter-clockwise angular acceleration $\alpha=4\ \text{rad/s}^2$ is applied until the EP is spinning counter-clockwise with $|\omega_f|=4$ rad/s (you'll need to determine the time to get to ω_f first)

A) 0 rads

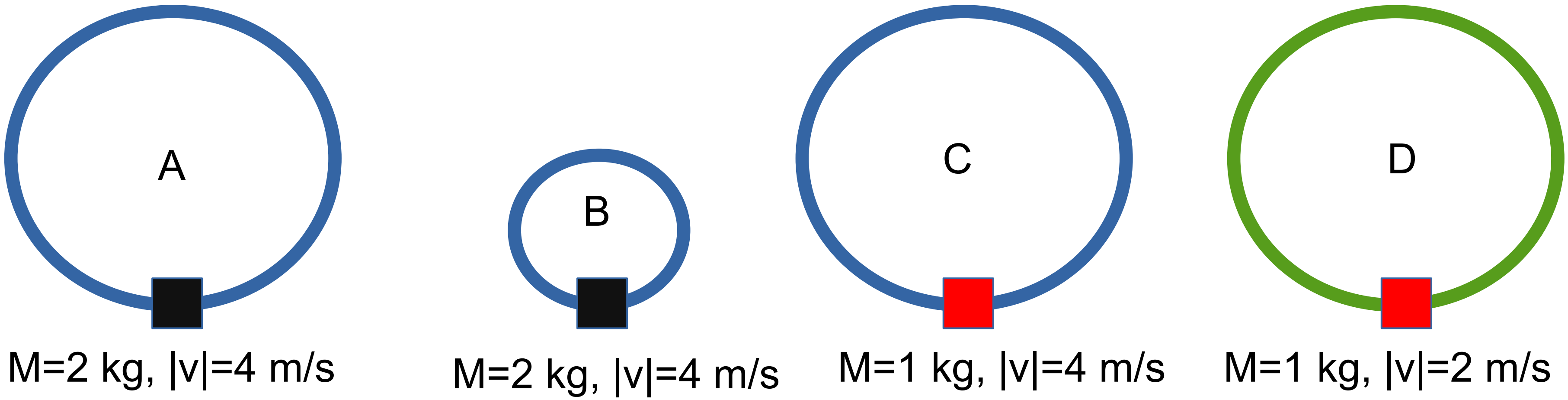
B) +16 rads

C) -16 rads

D) 64 rads

E) NOTA

Rank the 4 cases shown, from smallest F_{net} acting on the mass to largest



A) A>B>C>D

B) B>C=D>A

C) A>B=D>C

D) D=C=B>A

E) B>A>C>D

Connecting linear velocites to angular velocities: $v=\omega r$

A 2 kg Hot Wheels™ car is confined inside of an 8m diameter Loop-de-loop. If the velocity magnitude is constant at 8 m/s, what is the magnitude of the normal force at the top of the Loop-de-loop?

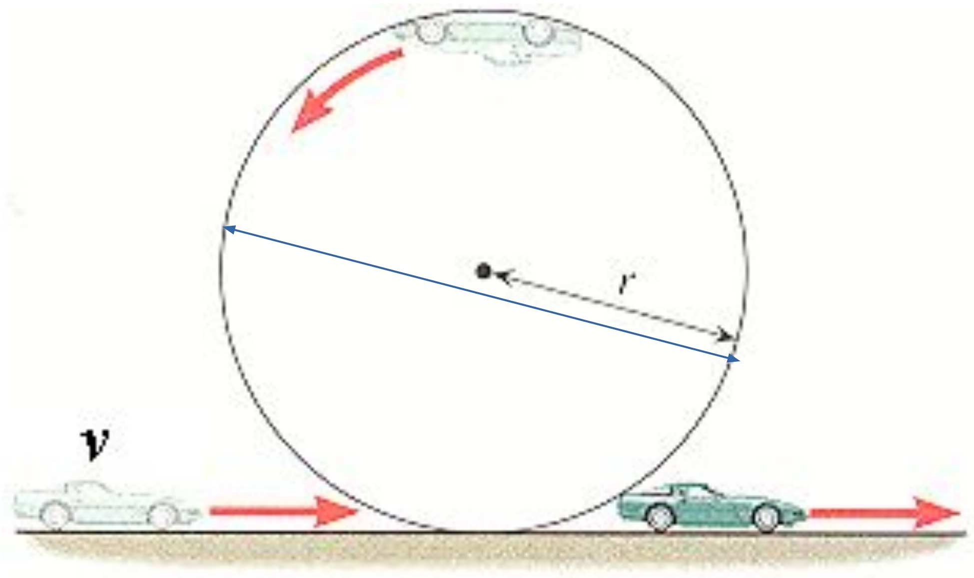
A) 19.6 N

B) 51.6 N

C) 12.4 N

D) 32 N

E) NOTA



In the previous problem, suppose you are told that the car is moving at 6 m/s. Use graphical addition of vectors (only) to estimate the magnitude of N at the bottom of the Loop-du-loop

A) 0 N

B) 19.6 N

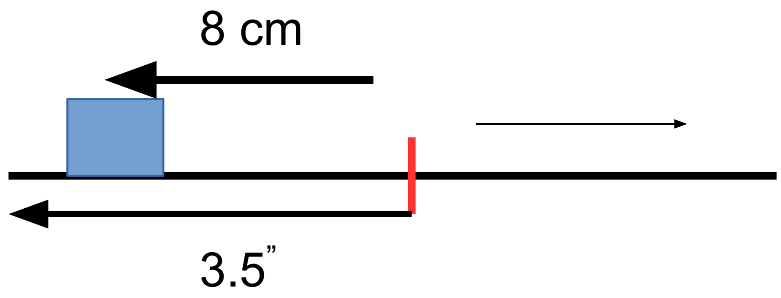
C) 38.2 N

D) 57.8 N

The Shannon's Dress 7" spins on a turntable with |v|=0.4 m/s; a 10 gram (0.01 kg) mass rotates with the EP 8 cm from the center, without slipping. The total number of forces acting on the mass along x-, and the magnitude of the frictional force, is:

A) 1, 0.2 N B) 1, 0.4 N C) 2, 0.4 N D) 1, 0.02 N

B) E) NOTA

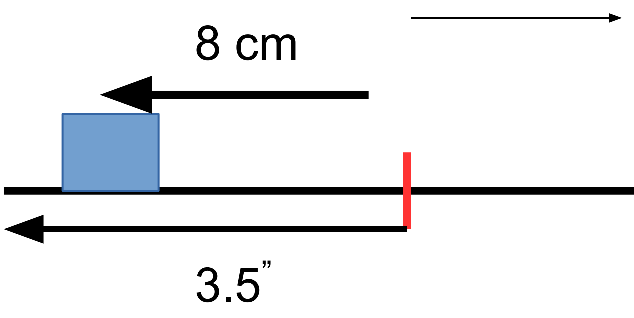


Part b) As the rotational velocity increases, how many forces increase in magnitude?

A) 0 B) 1 C) 2 D) 3 E) NOTA

The Shannon's Dress 7" spins on a turntable; a 10 gram (0.01 kg) mass rotates with the EP 8 cm from the center. If μ_s=0.5, determine the maximum velocity before the mass begins to slip

A) 0.063 m/s B) 0.63 m/s C) 6.3 m/s D) NOTA



Now suppose the EP is rotating at an angle relative to the horizontal with the same angular velocity ω. In that case, the centripetal force

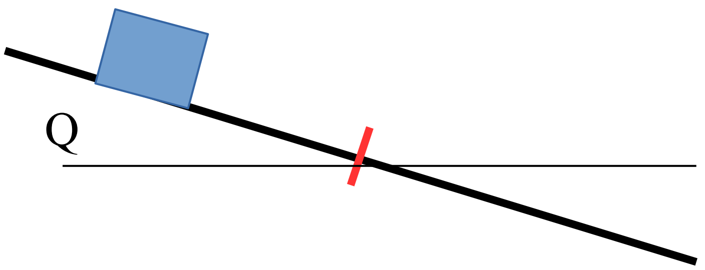
A) Has the same magnitude, but different direction

B) Has larger mag., and different direction

C) Smaller mag/same direction

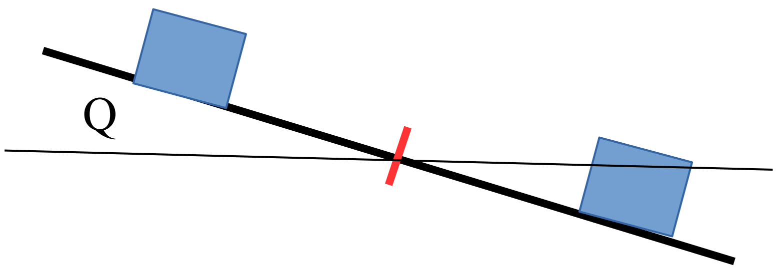
D) Smaller mag/different direction

E) NOTA



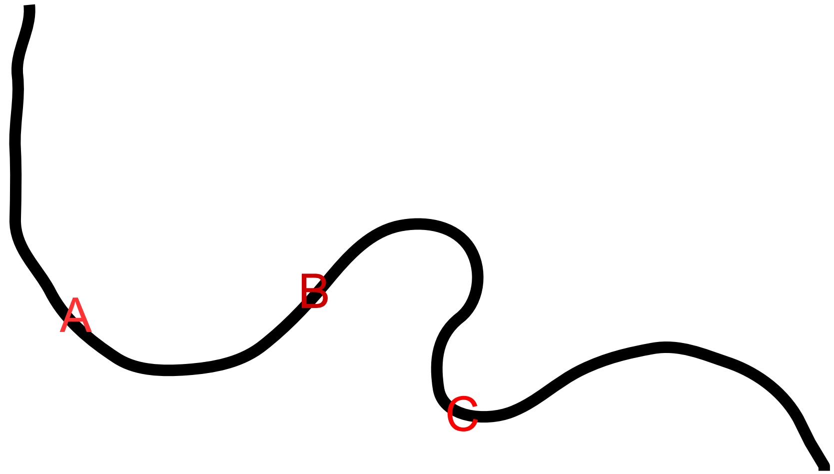
Now suppose the EP is rotating at an angle relative to the horizontal with the same ω. In that case, which of the following forces have different magnitude between top/bottom?

A) $|F_{friction}|$
B) $|N|$
C) |Gravitational|
D) Two of the above
E) NOTA



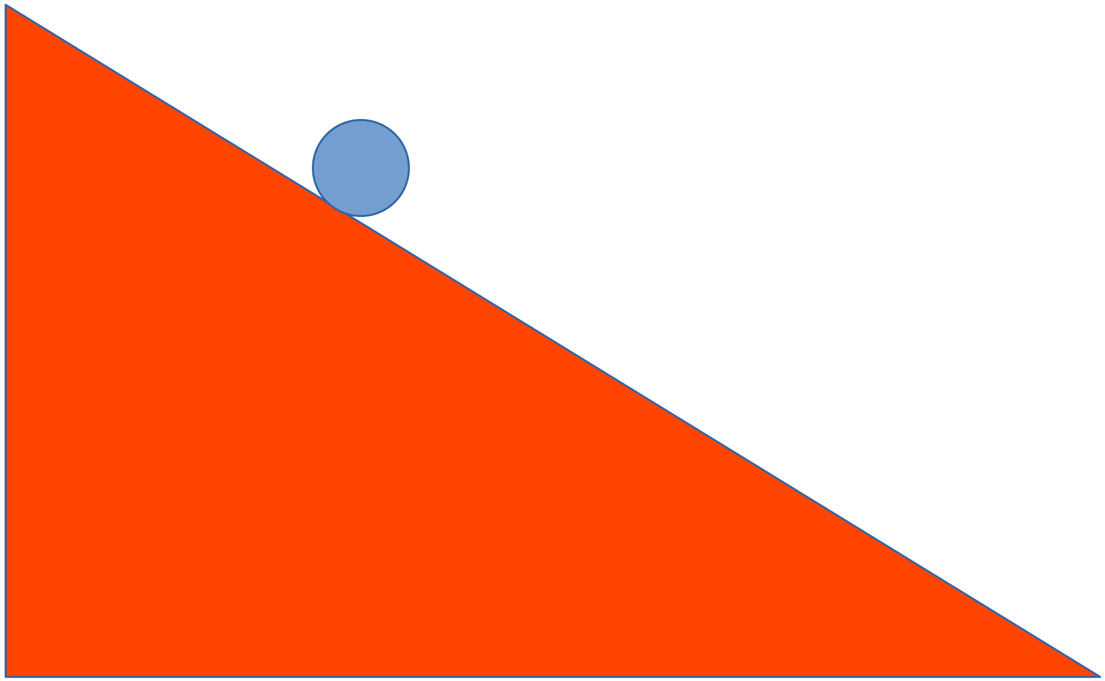
Laika, the wonder dog, runs along the treadmill shown at constant speed. Rank the magnitude of the net force on him at the three points shown

A) $F_A > F_B > F_C$ B) $F_B > F_A > F_C$ C) $F_C > F_B > F_A$ D) $F_C > F_A > F_B$



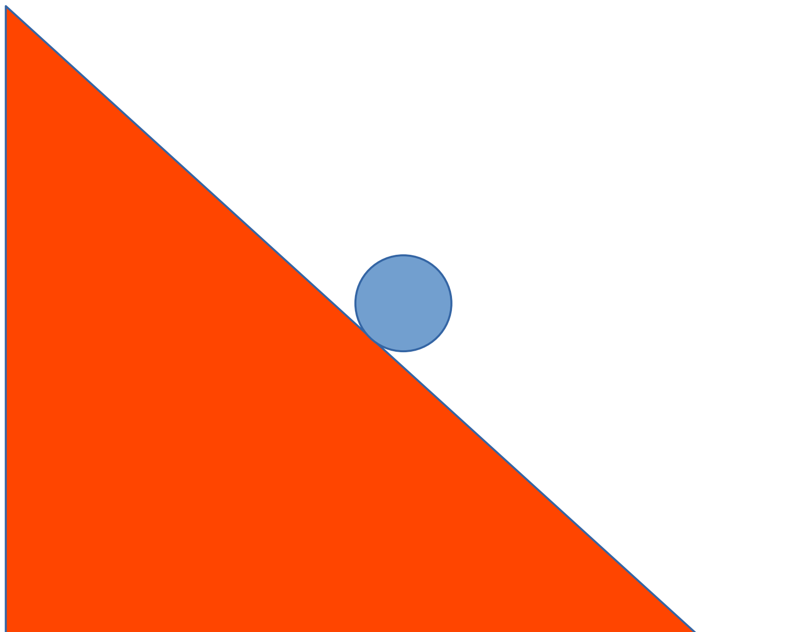
Imagine previous problem as mass getting a transverse “kick” which is in the direction of the radial acceleration a_r

A car is racing around a banked track at constant velocity. Given what you know about the direction of acceleration for circular motion, as viewed from above, in which direction is the car's acceleration?



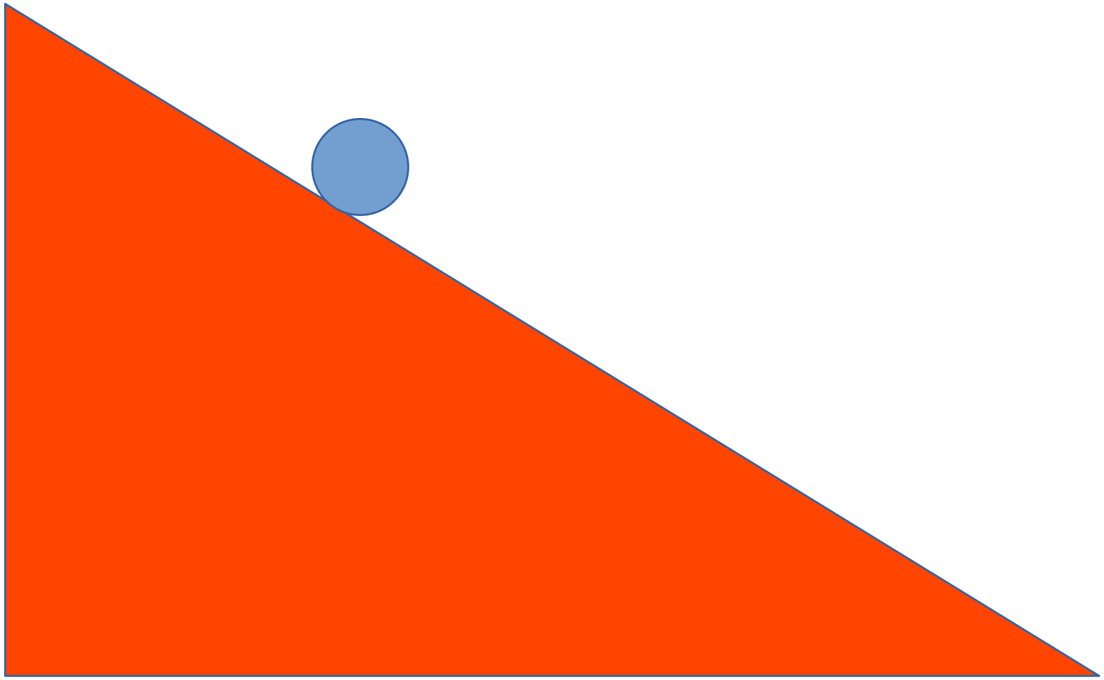
A) up
B) down
C) to the right
D) to the left
E) down the incline

A 4 kg car on a frictionless track moves with constant velocity. The magnitude of the normal force on the track is about



A) 20 N
B) 40 N
C) 60 N
D) 80 N
E) 100 N

A 4 kg mass on a frictionless incline has an acceleration vector as shown. After estimating the magnitude of the Normal force on m, the magnitude of the acceleration is about:



A) 7.5 m/s^2
B) 12.5 m/s^2
C) 15 m/s^2
D) 20 m/s^2
E) 30 m/s^2

Ken Kesey drives his 100-kg Further bus around a frictionless track at a bank angle of 60º. From a force diagram, you can conclude that:

A) N=mg

B) N<mg

C) N>mg

From the information given, if the radius of the 60° banked track is 200 m, the velocity of the 100-kg Further bus is about:

A) 45.2 m/s

B) 58.3 m/s

C) 66.4 m/s

D) 78.2 m/s

E) NAFTA

Ken Kesey now begins to gun the accelerator pedal, and the car begins to drift up the track as it speeds up. As this happens, which statement below is true?

A) Both components of the normal force on the car increase

B) One component of the normal force increases

C) The Normal force magnitude decreases

D) The magnitude of the net force remains constant

E) NOTA

https://www.youtube.com/watch?v=mHy5caF7REY

Suppose there is friction on the track to keep the car from sliding up on the track. As KK guns on the accelerator pedal, which statement is true?

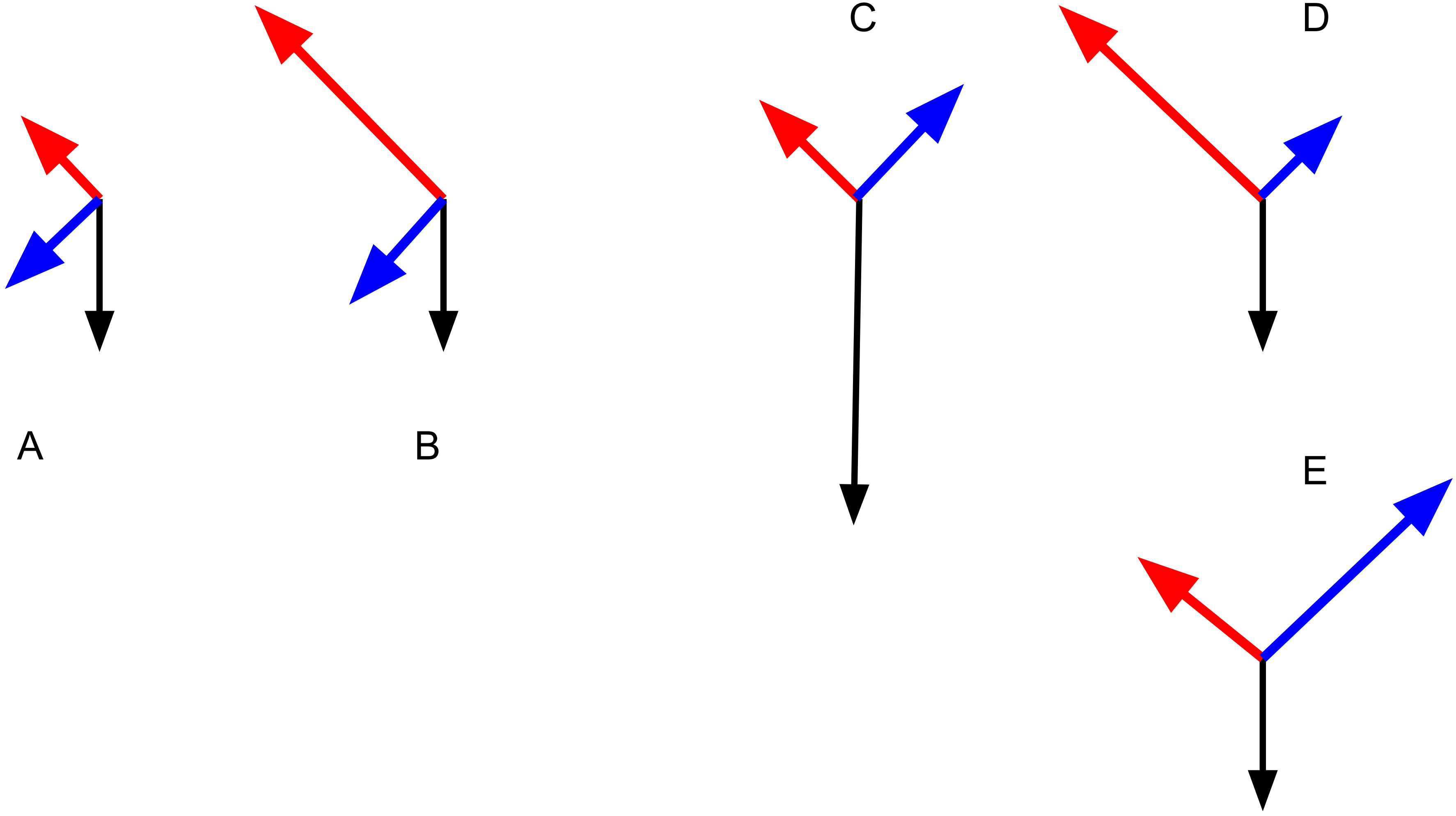
A) Only the Normal force magnitude increases.

B) Only the frictional force magnitude increases.

C) Both F_f and N increase.

D) Neither friction nor N must increase as the bus speeds up.

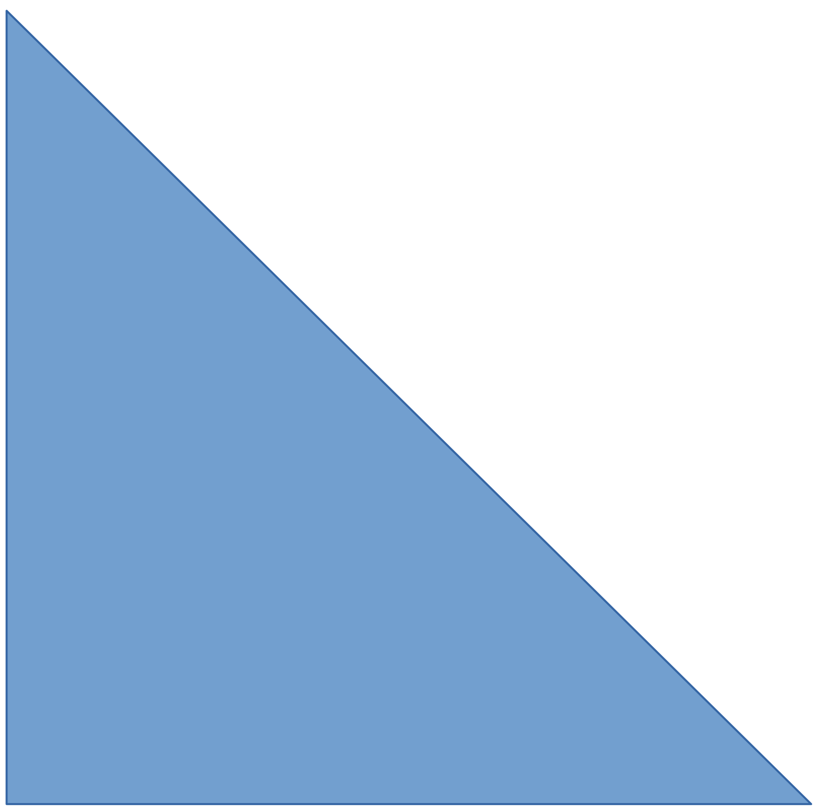
KK now begins to gun the accelerator pedal, and the car begins to drift up the track as it speeds up. Just before it starts to drift up the track, which of the following is a possible force diagram? (black=gravity; red=normal; blue=friction); reminder that $m_s<1$



https://www.youtube.com/watch?v=mHy5caF7REY

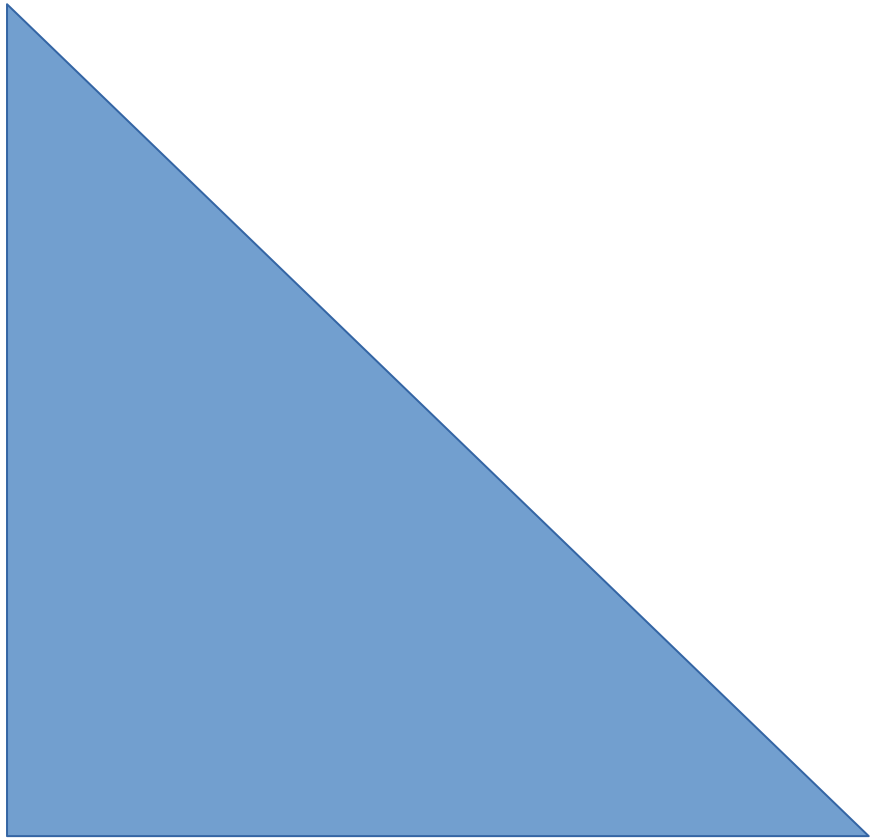
A 4 kg car on a 45^o rough banked track of radius 20 m has an 80N normal force acting on it. The velocity of the car is about

A) 5 m/s
B) 20 m/s
C) 35 m/s
D) 50 m/s
E) 75 m/s



A 4 kg car on a 45^o rough banked track of radius 20 m has a 100N normal force acting on it. The frictional force is about

A) 10 N
B) 30 N
C) 60 N
D) 100 N



Summary of car-on-track problems:

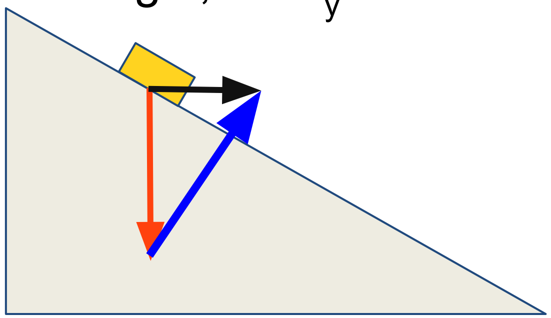
$F_{net}=m\mathbf{a}_{net}$;

generally, 3 forces: Gravity + Normal + friction. Start by drawing gravity and ma_{net} to scale relative to each other. Normal is perpendicular to surface, and added to gravity and friction, gives F_{net}. If $v_{no\ friction}$ is the velocity for the case where there is no friction, then for $v<v_{n.f.}$, the frictional force is UP along the incline to prevent the mass sliding down. For $v>v_{n.f.}$, the frictional force is DOWN along the incline.

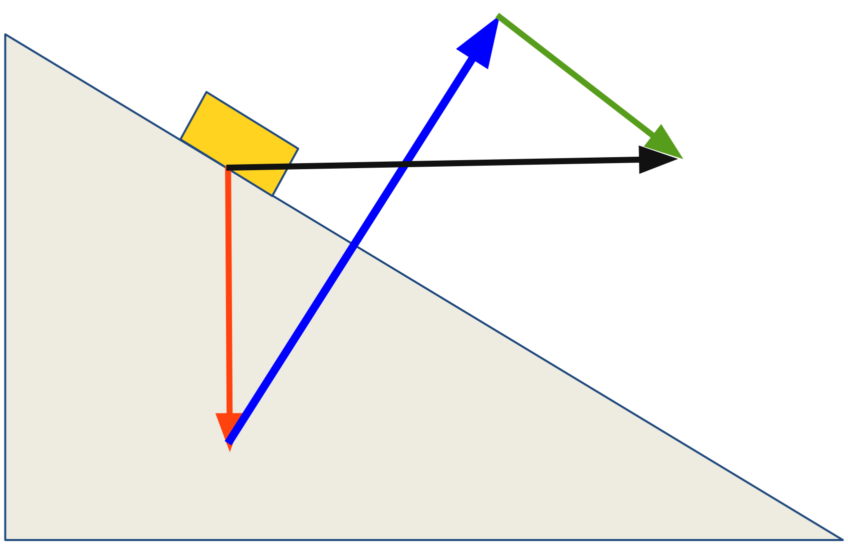
$v_{n.f}$. depends on on incline angle and radius of track

Inputs: track bank angle=30°; r=10 m; μ_s=0.5; m=5 kg (as it turns out, result independent of m!)

Frictionless case: Add N until net force horizontal ($F_r = mv^2/r$). First, estimate v graphically from diagram: $mv^2/r \sim 25$ N, so $5v^2/10 = 25$ N, so v~7.1 m/s. Next, solve numerically: N_x=mg; angle wrt vertical=bank angle, so $N_y = N\cos 30° = mg$; N=56.6 N; $mv^2/r = N\sin 30 = 28.3$N; v= 7.5

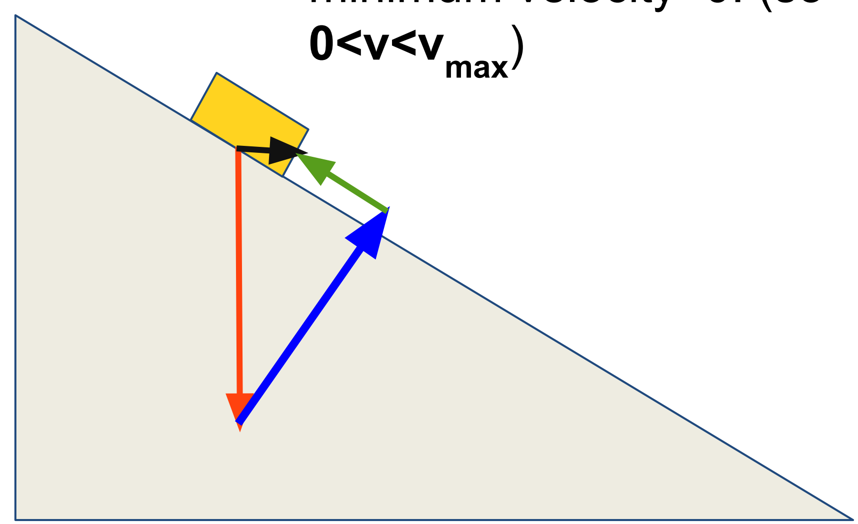


Maximum velocity case: Mess with F_s and N until resultant is horizontal; F_s down incline to prevent sliding up incline with magnitude half as large as N (μ_s=0.5); $mv^2/r \sim 1.5$x mg, or 75 N, so v~12.2 m/s



Minimum velocity case: Mess with F_s and N until resultant is horizontal; F_s UP incline to prevent sliding down incline with magnitude half as large as N (μ_s=0.5); $mv^2/r \sim 0.2$ x mg, or 10 N, so v~4.4 m/s

What if you picked μ_s=0.7? minimum velocity=0! (so $\mathbf{0<v<v_{max}}$)



A 2 kg mass is swinging on a string of length 2.5 m, which makes an angle of 53.1° below the horizontal. The number of forces acting on the mass, and the radius of the mass' circular motion is:

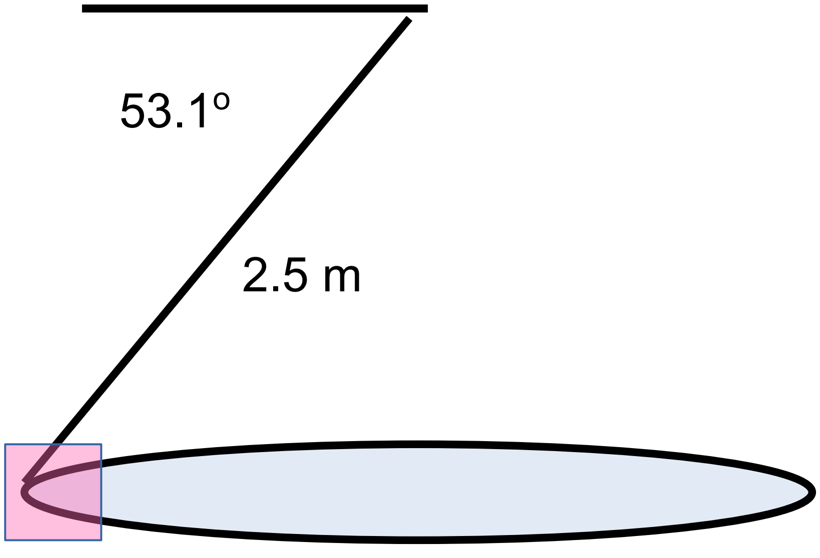
A) 3, 2 m

B) 2, 1.5 m

C) 3, 1.5 m

D) 2, 2 m

E) NOTA



If m=2kg, then, from a force diagram, the tension in the 2.5 m cable shown is about:

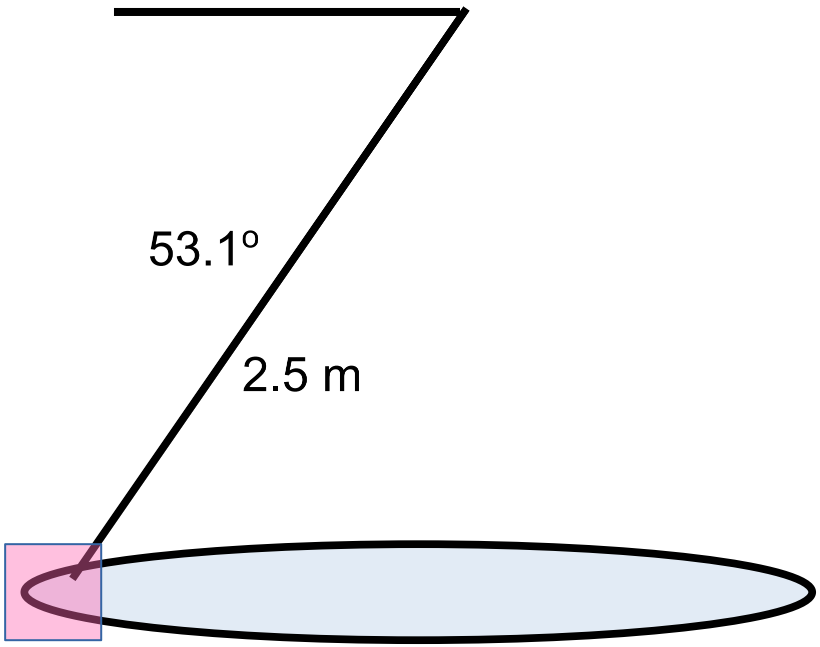
A) 10 N

B) 20 N

C) 28 N

D) 45 N

E) 70 N



In the previous problem, the value of the velocity as the mass is rotating is numerically equal to:

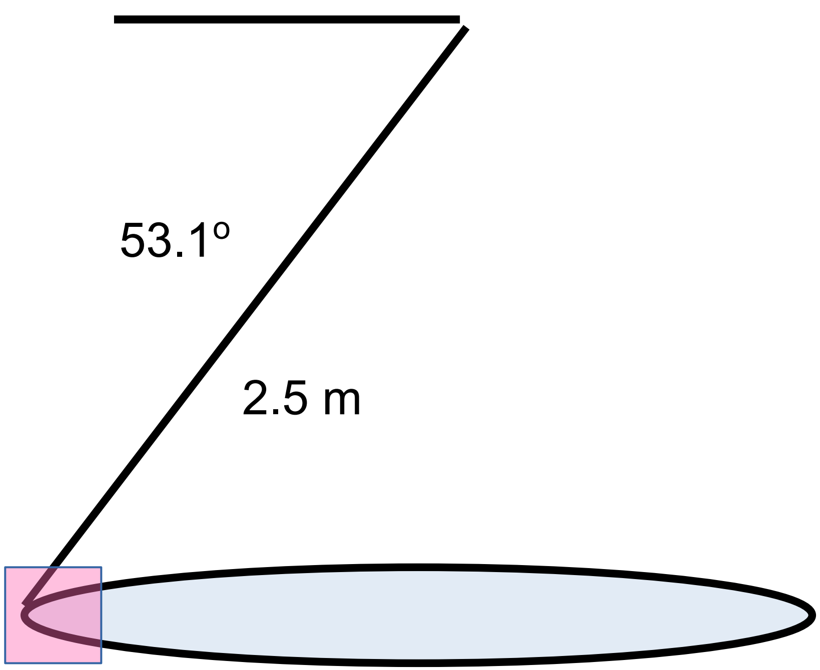
A) 2.71 m/s

B) 3.32 m/s

C) 4 m/s

D) 4.8 m/s

E) NOTA



The angle wrt horizontal is now decreased so the mass is rotating more ‘horizontally’; mass now rotates with a new constant velocity v'; there is also a new tension T'. Which of the following is true?

A) $T_x' = T_x$; $T_y' = T_y$

B) $T_x' > T_x$; $T_y' = T_y$

C) $T_x' > T_x$; $T_y' > T_y$

D) $T_x' < T_x$; $T_y' < T_y$

E) NOTA

At one instant of time, a 4 kg mass executes circular motion of radius r=4m under the influence of 2 forces: 24 N acting at +60° and 20 N acting at +126.87° (both wrt +x). From the information given, what is the approximate velocity of the mass and which arrow could describe the direction of the mass' motion?

A) 1.8 m/s $\downarrow$

B) 3.2 m/s $\rightarrow$

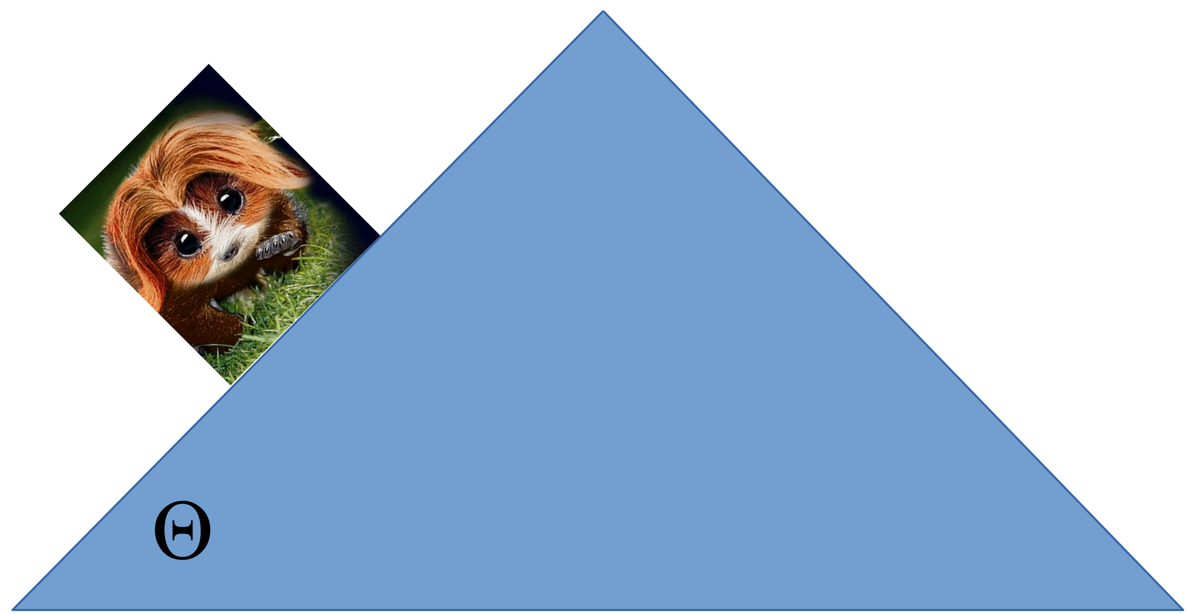
C) 3.0 m/s $\uparrow$

D) 7.2 m/s $\rightarrow$

E) 3.0 m/s $\downarrow$

By drawing a force diagram, determine whether a 20-kg Scottish haggis can run around the Scottish highland shown. Remember that friction cannot exceed the magnitude of the Normal force

A) For $\Theta<45^o$, it can, for $\Theta>45^o$, it can't. B) For all angles, it can. C) The Haggis will never, ever, ever, ever run around this mountain.



In der Roten Riden, the centripetal acceleration is provided by

A) $F_{friction}$

B) $N_{wall\ on\ person}$

C) Mg

D) Two or more of the above

E) NOTA

In роторная поездка, if μ_s=0.2 and r=2 m, the minimum velocity such that a 50 kg person is "stuck" to the wall is about:

A) 2 m/s

B) 3 m/s

C) 4.4 m/s

D) 6 m/s

E) 10 m/s

In der Roten Riden, the minimum rotational velocity ω (=v/r) required to constrain someone against the wall is (assume μ_s is the same for all riders):

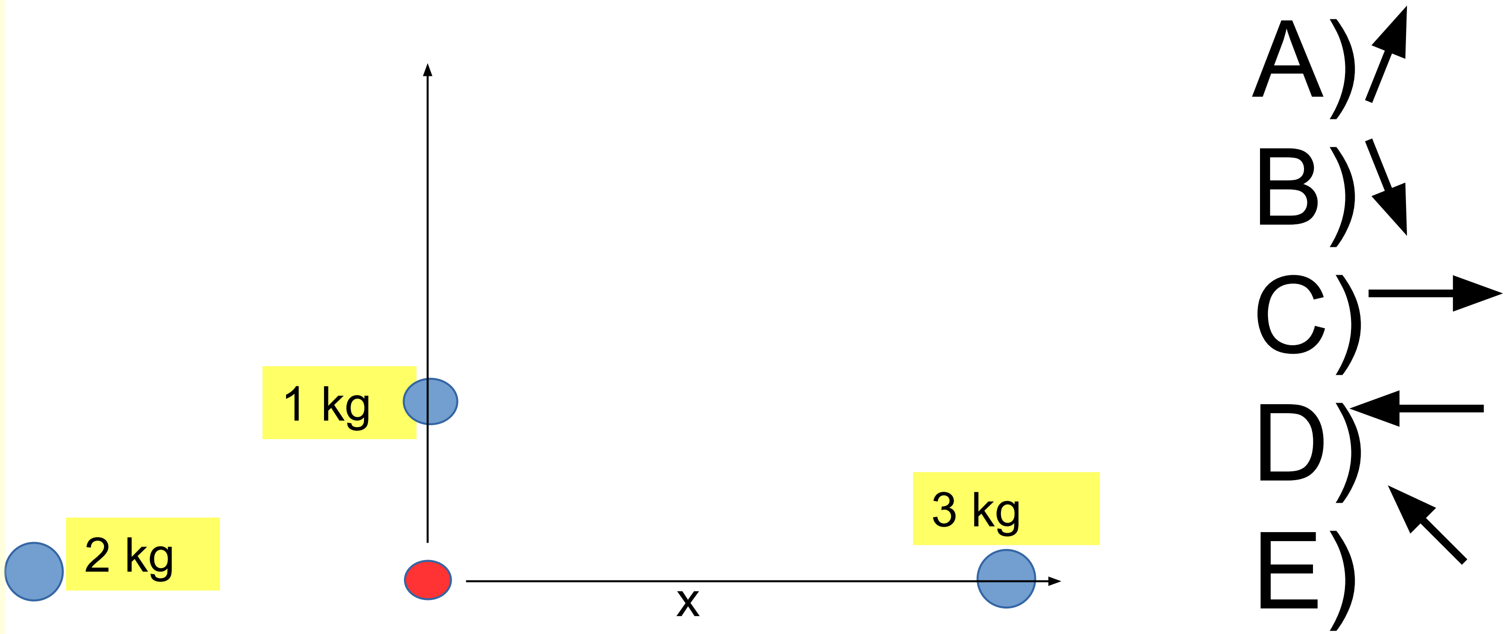
A) The same for all `riders'.

B) Larger for larger riders.

C) Larger for smaller riders

Gravitation: $\mathbf{F}_{1,2}=GMm/r^2$ (attractive!). Which arrow best gives the acceleration (i.e., g field) for a 2 kg "test mass" m at the origin, under the influence of the 3 "source masses" shown?

(distances are 1m (1 kg), 2m (2 kg), and 3m (3 kg), respectively.)



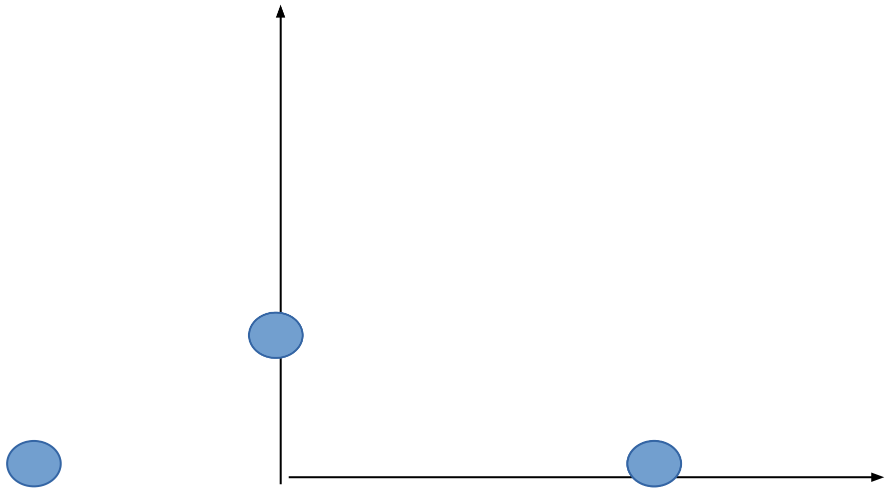
The x- and y-components of the net gravitational force on the mass are:

A) -0.33 G, +2 G

B) -0.167 G, +1 G

C) -1 G, 1 G

D) NOTA



Assuming that the moon has a density about 60% that of Earth, and that the radius of the Earth is 15% that of Earth, then, on the surface of the moon, the value of the gravitational constant g_{Moon} =

A)
B)
C)
D)
E) NOTA

The Earth is about 8 ½ light-minutes from the Sun. Based on that fact, and combined with t_{year}(seconds), you can estimate M_{Sun}~

A) 2 x 10^{21} kg

B) 2 x 10^{24} kg

C) 2 x 10^{27} kg

D) 2 x 10^{30} kg

E) NOTA

From your previous answer, the speed of a chunk of space dust, orbiting the sun at a distance of 200 light-days is about:

A) 150 m/s

B) 1500 m/s

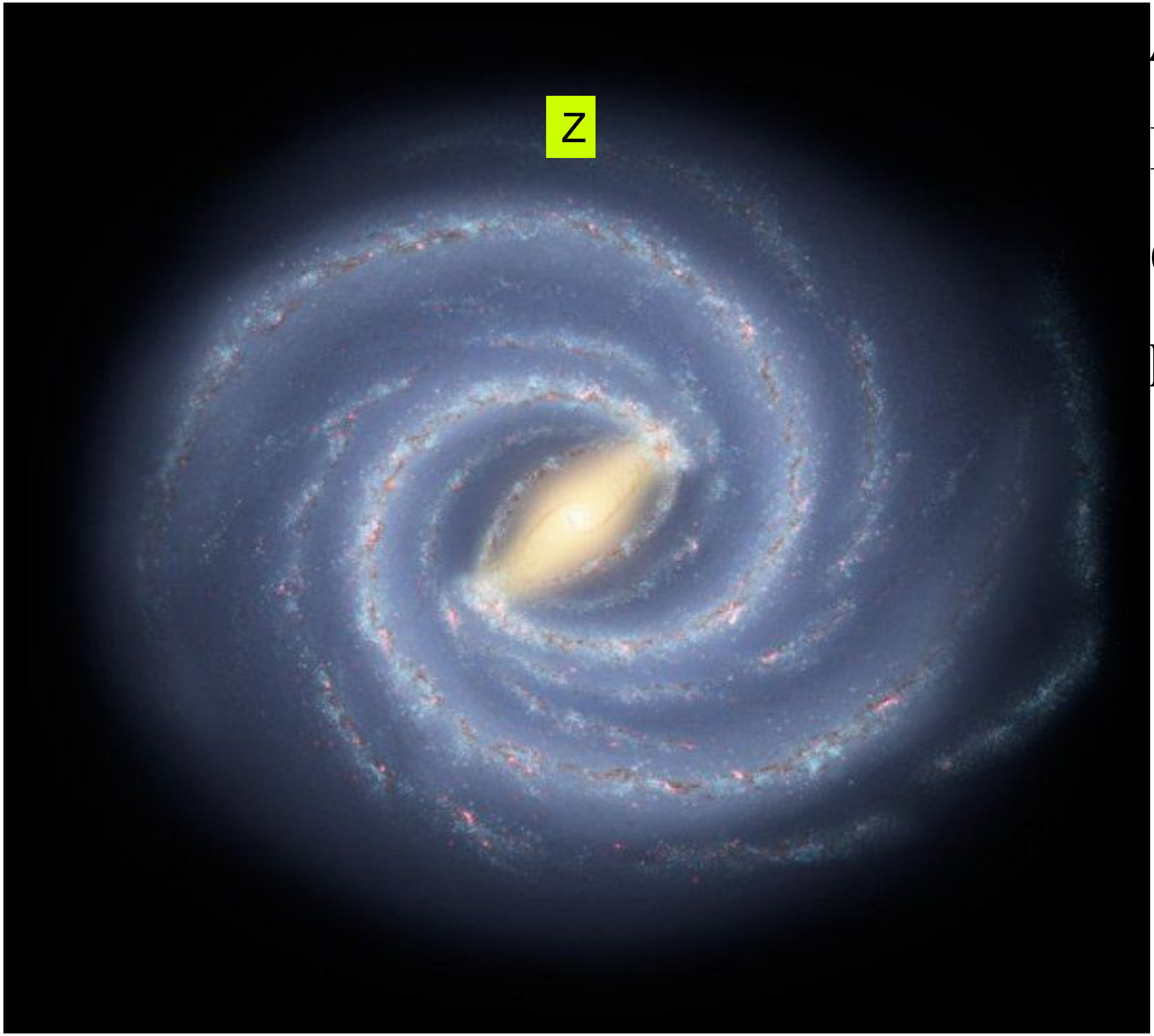
C) 15000 m/s

D) 150,000 m/s

E) NOTA

The moon is 384,400 km from Earth. Based on your knowledge of how long it takes the moon to rotate around the Earth, estimate the mass of the Earth

What is the wavelength of light observed from star Z ($c=3 \times 10^8$ m/s; $f_{Yellow}=5 \times 10^{14}$ Hz; $r_{galaxy}=20$ kpc; 1 pc$=3 \times 10^{16}$ m; 1 Galactic Yr$=2.5 \times 10^8$ Solar years; 1 year$=3 \times 10^7$ s)



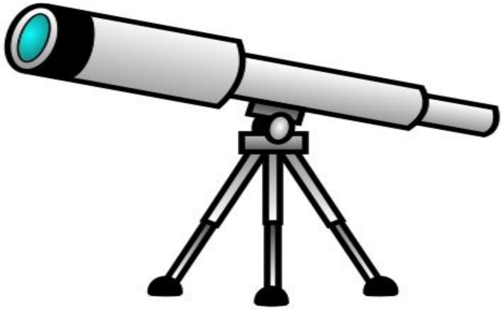
A) 600.96 nm

B) 599.04 nm

C) 590.6 nm

D) 600 nm

E) NOTA



ELSEVIER

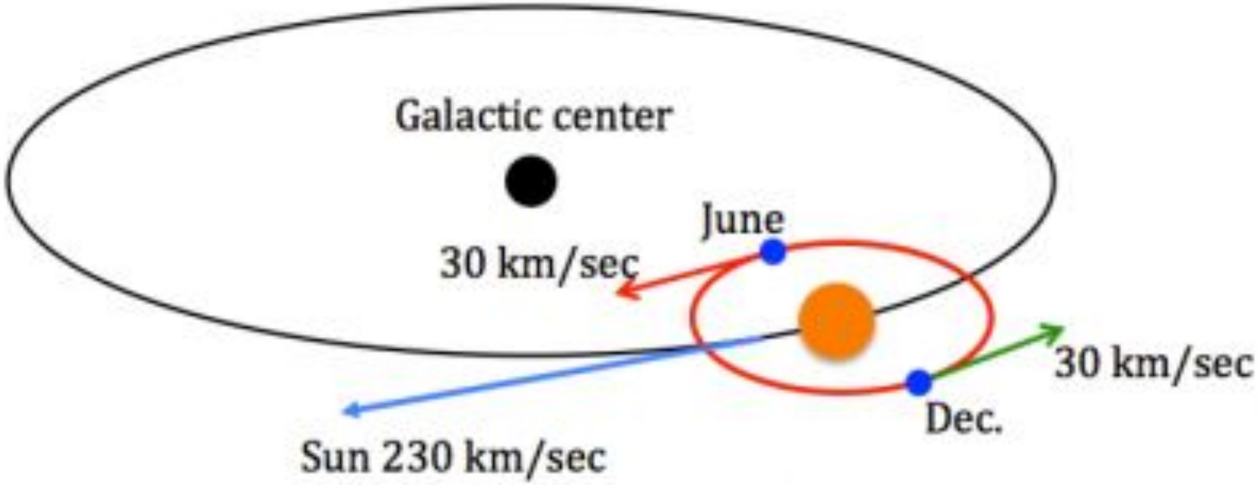
Physics Letters B
Volume 242, Issue 2, 7 June 1990, Pages 257-264

Evidence of dark matter from biological observations

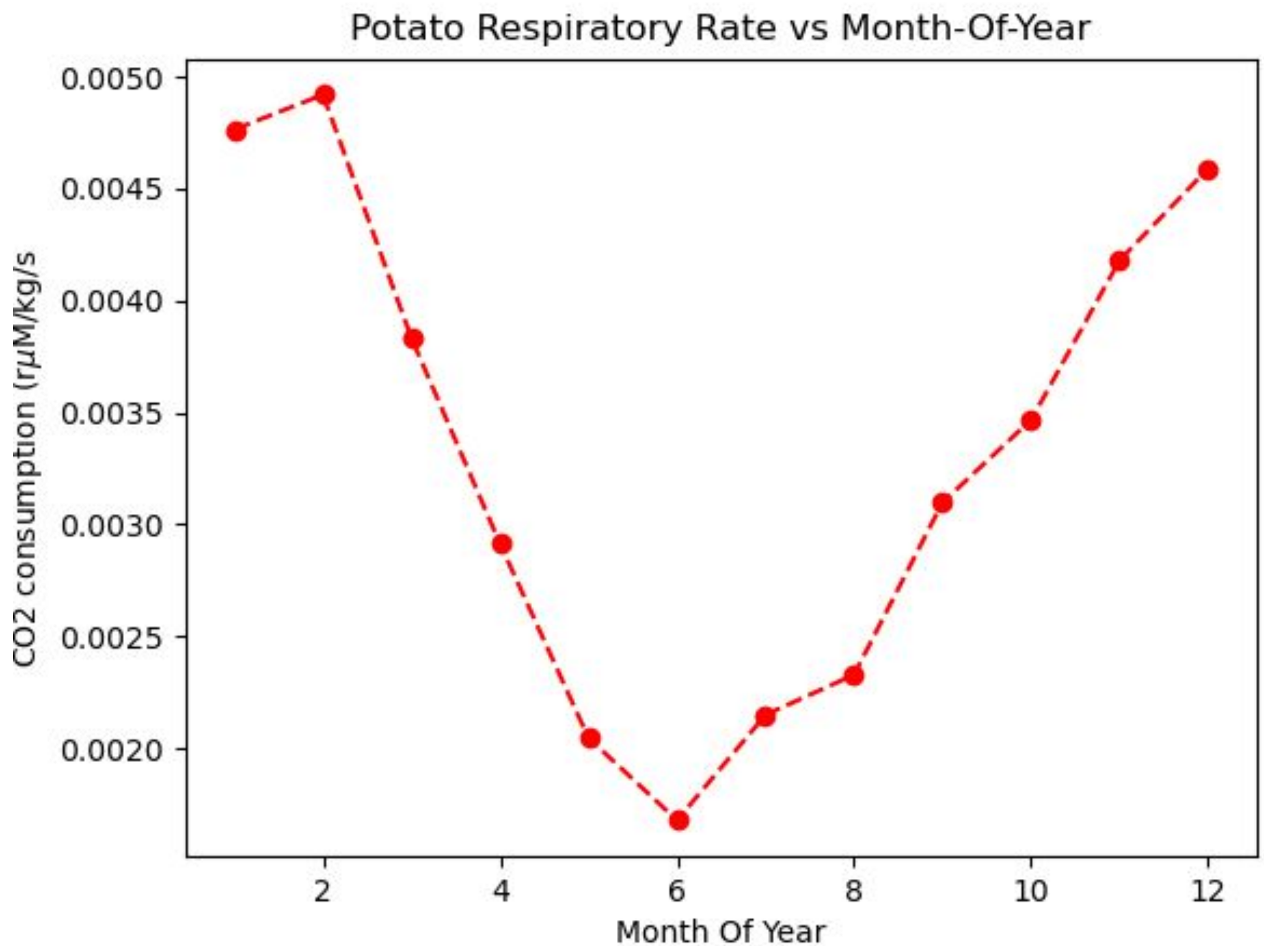
Konstantin Zioutas

Abstract

In accordance with the generally accepted properties of dark matter (DM) candidates, the probability of their interaction with living matter must be equal to that for inorganic matter, and the expected effects might be unique and provide the etiology related to the appearance of several biological phenomena having sometimes fatal late effects. Although collisions with DM are rare, the charged secondaries (recoiling atoms) are expected to be high linear energy transfer particles favouring the highest relative biological effectiveness values for this, as yet invisible, part of the natural background radiation. A few cases are given, where a correlation between DM interaction and phenomena in living matter might already exist, or can show up in existing data: biorhythms w with periodicities identical to known cosmic frequencies are explainable with gravitationally clustered DM around the sun, the moon, the earth, etc. The observed arrhythmia, when biological probes are moved (in airplanes, satellites, etc.) support this idea strongly. It is also proposed to implement some of the biological properties and processes (such as element composition and chemical reactions) in future DM detectors in order to improve their sensitivity. The interdisciplinary feedback is bidirectional: huge DM detectors could be used in attempt to understand enigmatic biological behavior.



Galactic center
June
30 km/sec
30 km/sec
Dec.
Sun 230 km/sec



Potato Respiratory Rate vs Month-Of-Year
CO2 consumption (rμM/kg/s
0.0050
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
2
4
6
8
10
12
Month Of Year

Ch. 7: Energy:

F=ma OK, but hard when lots of forces

Alternative: Object will follow a path for which KE+PE is a minimum (principle of least action).

Applies to EVERYTHING!

1) $PE_{grav}=mgh$; 2) $PE_{spring}=kx^2/2$; 3) $KE=mv^2/2$

4) $W_i=|F_i||d|\cos\theta_{d,F}$ = $F_{||}d$ (+/-1 by hand)

5) $W_{net}=\Delta(KE)$ 6) for springs/grav; $W=-\Delta(PE)$

N.B.: Energy conservation (time-invariance symmetry); note similarity:

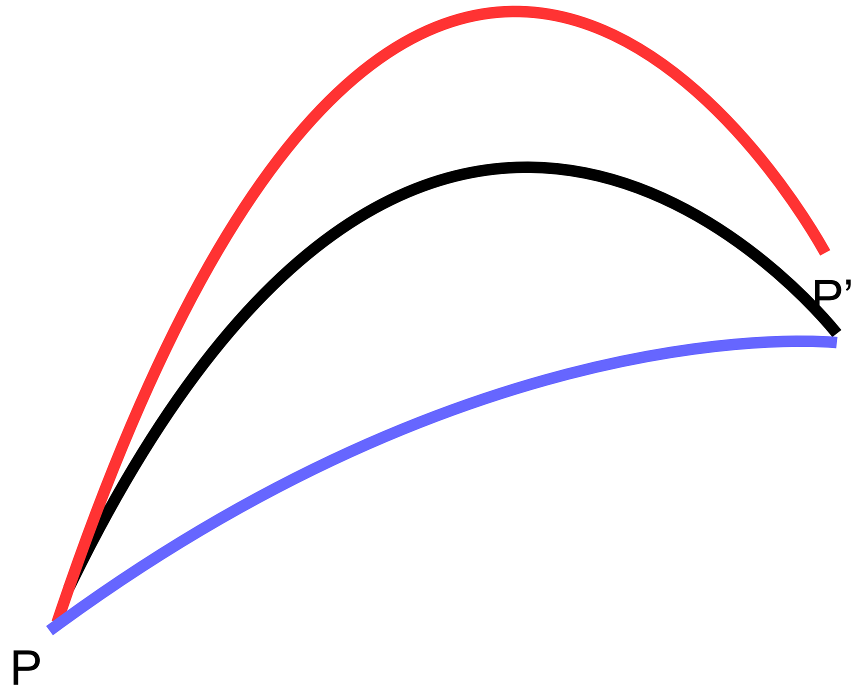
$S\mathbf{F}_i=\mathbf{F}_{net}=m\mathbf{a} \leftrightarrow SW_i=W_{tot}=D(KE)$

A ball is thrown from P → P' on Earth, and follows trajectory A. On Jupiter, the ball would follow which trajectory?

A) (black)

B) (red)

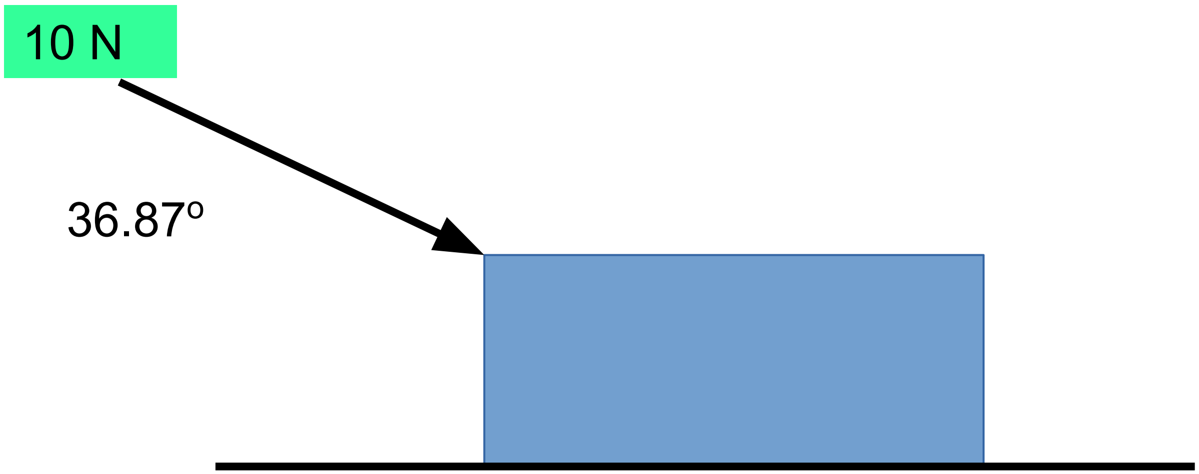
C) (blue)



Principle of Least Action: Correct trajectory is that which minimizes the sum of (KE-PE) from P→P'

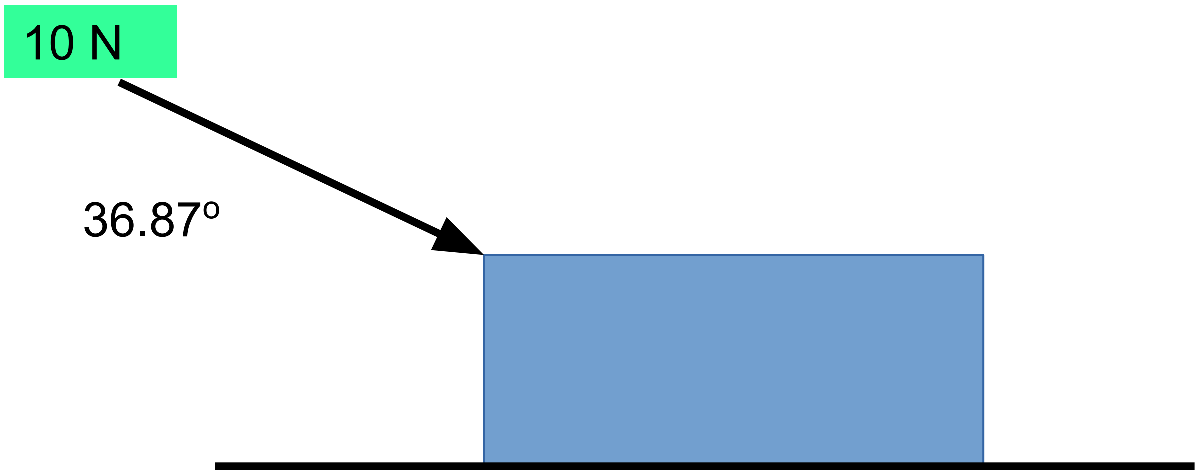
Laika, Le chien me demande, nudges a 2 kg box, starting from rest, across a rough surface with $a=3\ m/s^2$, by applying a force of 10 N, at the angle shown. The number of forces doing negative, zero, and positive work is:

A) 1,2,1 B) 2,1,1 C) 3,0,1 D) 1,3,0 E) NOTA



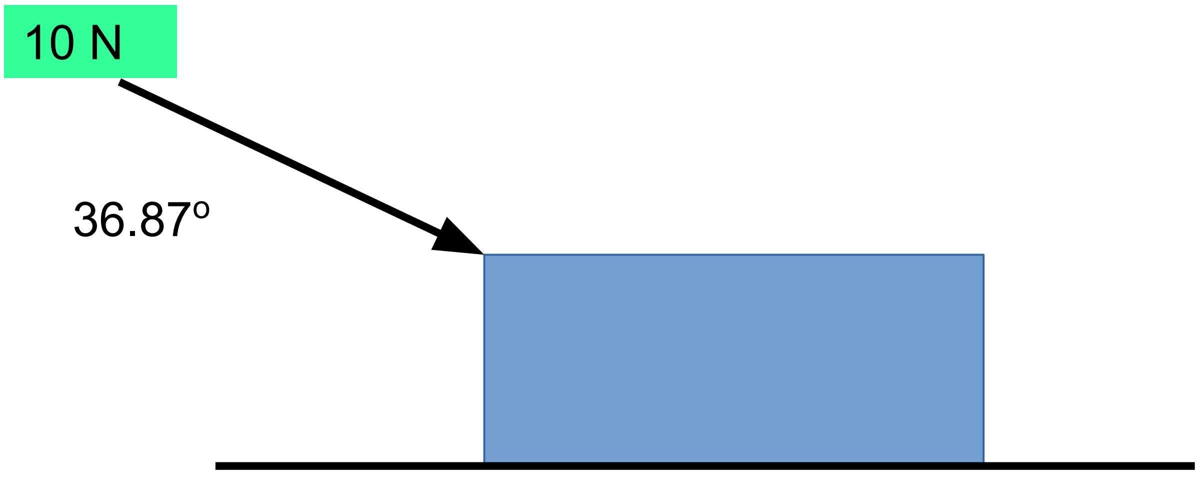
Laika, Le chien me demande, nudges a 2 kg box across a rough surface, starting from rest, with a=3 m/s^2, by applying a force of 10 N, at the angle shown. The magnitude of the frictional and normal forces, respectively, are:

A) 2 N, 25.6 N B) 8 N, 8 N C) 8 N, 25.6 N D) 2 N, 8 N E) NOTA



In the previous problem, using $W=|F||d|\cos\theta_{F,d}$, the value of $W_{frictional\ force}$ in 2 seconds, and the work done by the pushing force in 2 sec, are:

A) 12J, 48J B) -12J, 48J C) -36J, 12J D) -48J, 12J E) NOTA



Determine W_{tot} from either:

a) $v_f = v_i + at$ to get v_f, combined with $W_{tot} = \Delta(KE)$,

b) $W_{tot} = \Sigma W_i$, or

c) $W_{tot} = |F_{net}||d|\cos(\theta_{F,d})$, gives $W_{tot} =$

A) 12 J

B) 24 J

C) 36 J

D) 48 J

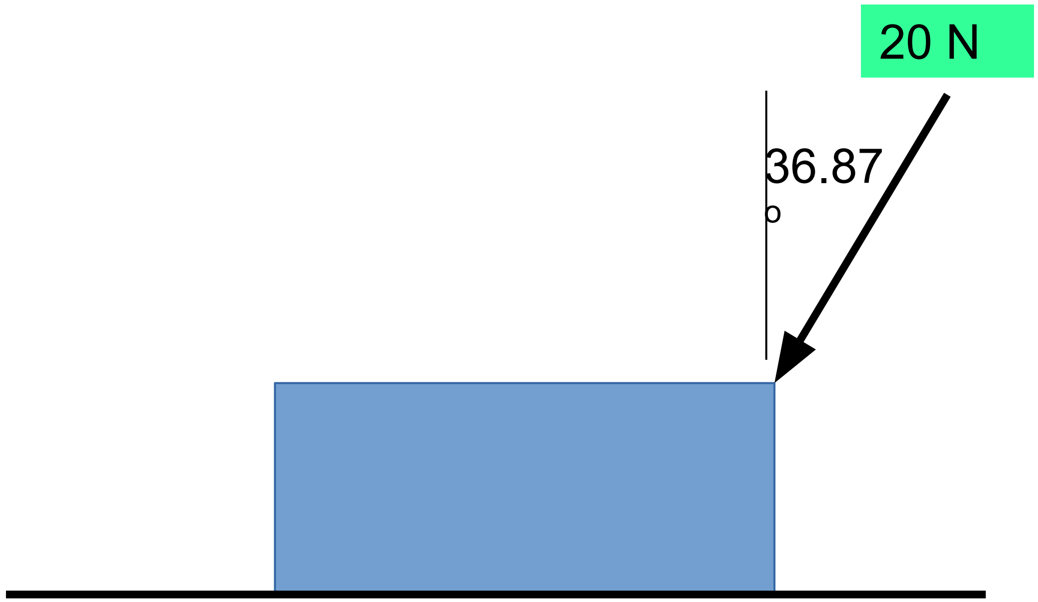
E) NOTA

As the angle Θ (wrt horizontal) increases, which of the following is/are true?

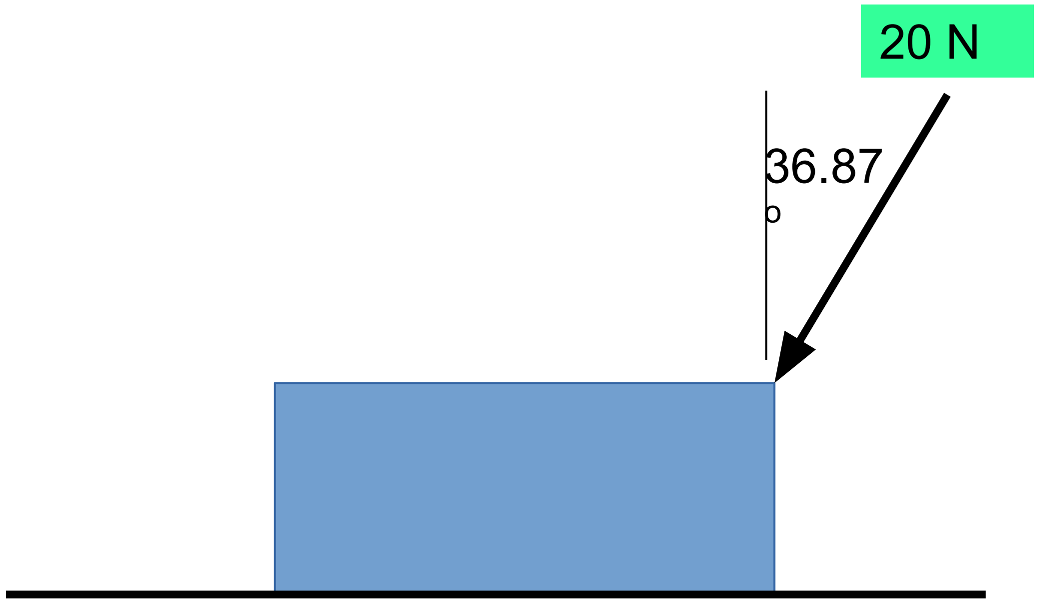
A) The Normal force increases
B) The frictional force increases
C) The acceleration increases
D) Two of the above are true
E) All of the above are true

A force is applied to the 4 kg mass shown, on a surface with μ_K=0.2, after calculating the magnitude of F_{net}, the total amount of work done after the box has moved a distance of 8 m is about:

A) 1 J
B) 8 J
C) 24 J
D) 48 J
E) 60 J



A force is applied to the 4 kg mass shown, on a surface with μ_K=0.2. a) estimate, from graphical addition the magnitude of F_{net}, and from that an estimate of the total amount of work done after the box has moved a distance of 8 m. b) Determine the work done by each force acting on the box, and then W=Δ(KE) to determine v_f numerically. c) check your result by determining the net force numerically in the x-direction, then solving for acceleration and using $x_f = \frac{1}{2}at^2$, combined with $v_f=v_i+at$



Laika,the Wonder Dog, uses a cable to pull a 2 kg box up a 10 m high rough, 30^o incline. The number of forces doing positive,negative, and zero work (respectively) on the box is:

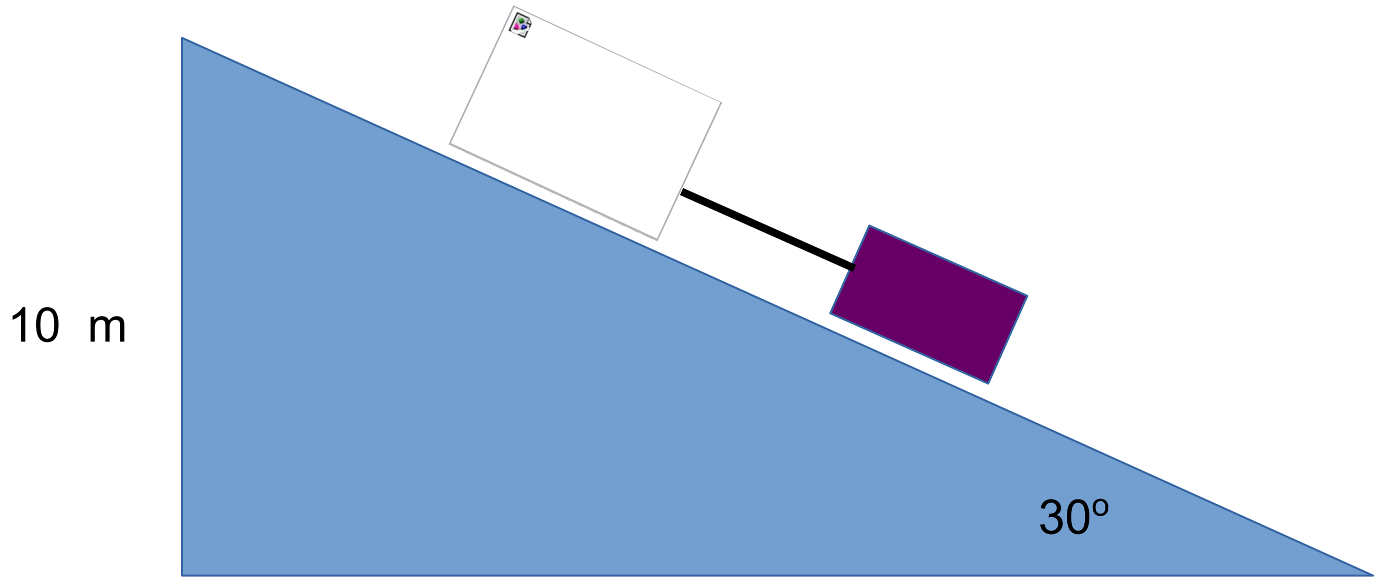
A) 2, 0, 2

B) 2, 2, 0

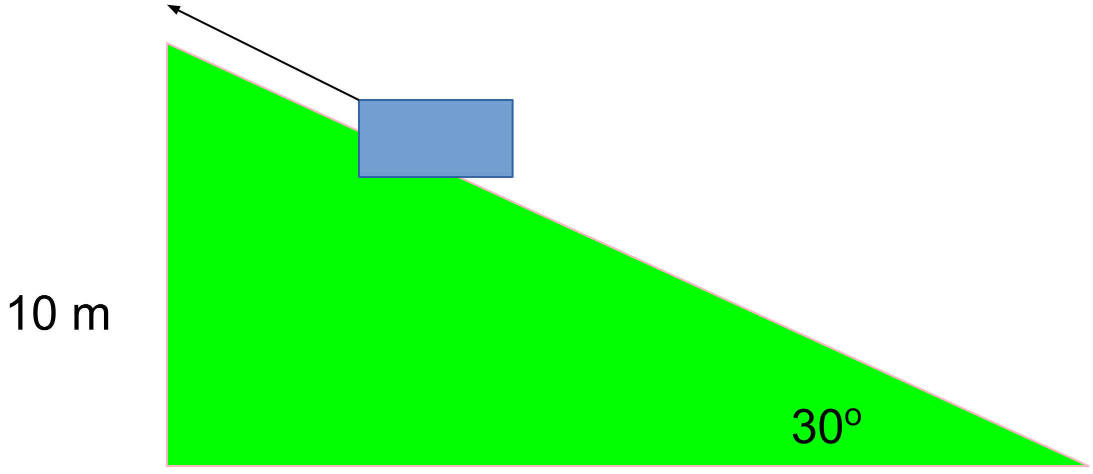
C) 2, 1, 1

D) 1, 2, 1

E) NOTA



A 2kg mass is pulled, at constant velocity v=5 m/s, up a 10 m high incline by a cable, as shown. The work done by the gravitational force, from bottom→top is:



A) 0 J

B) 196 J

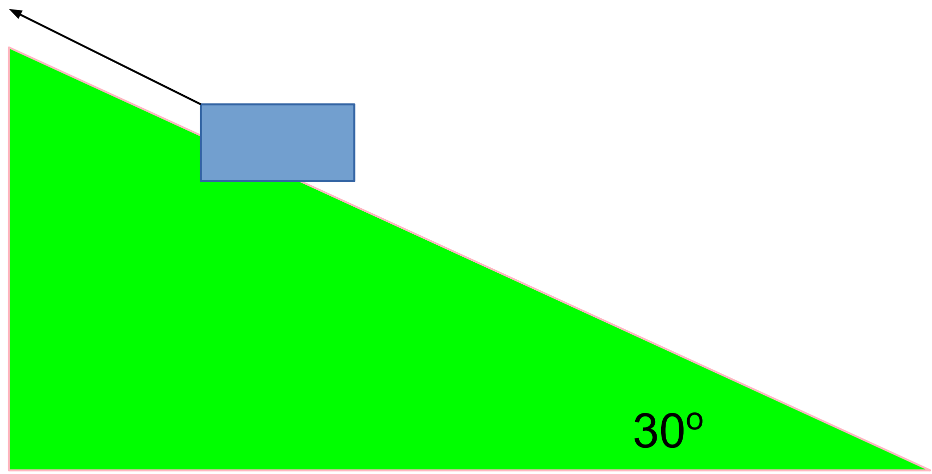
C) -196 J

D) -392 J

E) NOTA

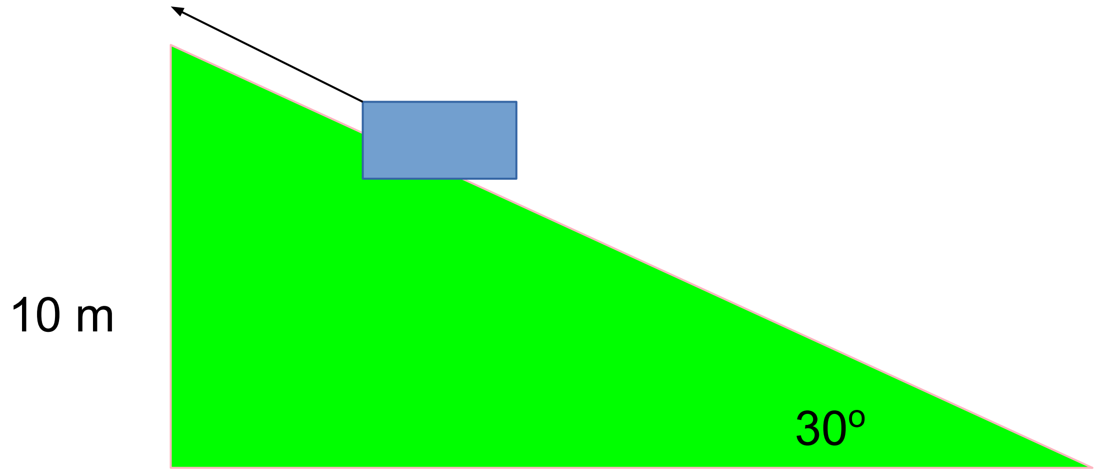
A 2kg mass is pulled, at constant velocity v=5 m/s, up a 10 m high incline by a cable, as shown. If the tension in the cable pulling on the mass is 16 N, and the mass moves at a constant velocity of 5 m/s, the work done by the frictional force on the mass is:

A) 6.2 J
B) -6.2 J
C) 124 J
D) -124 J
E) NOTA



what is the magnitude of the frictional force?

A) 3.1 N
B) 6.2 N
C) 9.3 N
D) 12.4 N
E) NOTA



Using W_{ext}=ΔPE+ΔKE+|heat|, determine the work done by the external force

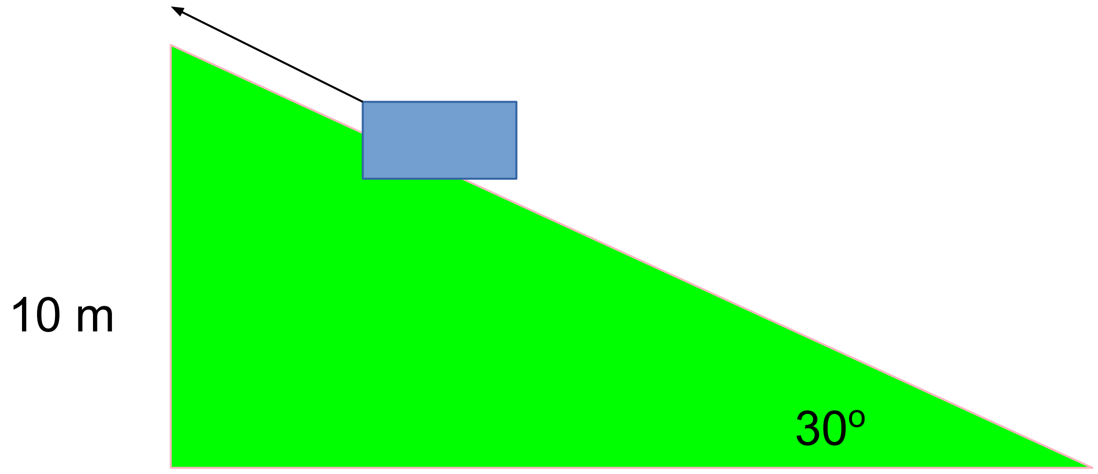
A) 32 J

B) 320 J

C) 196 J

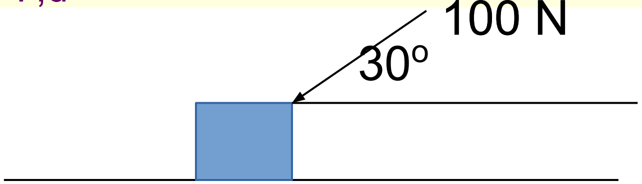
D) 124 J

E) NOTA



In the problem below, calculate **displacement** and $\mathbf{v_f}$ using F=ma, then check your answers using $W_{tot}=\Delta KE=\Sigma W_i$; with W_i the work done by each force i ($W_i=|F_i||\text{displacement}|\cos\theta_{F,d}$) as the mass moves over the distance d

Given: $\mu_k=0.1$; $v_i=0$ m/s, t=4s, m=2 kg



Solve for a, using $\Sigma f_x=ma_x$, and $\Sigma f_y=ma_y$; in y-direction, $a_y=0$, so 0=-(2kg)(9.8)+Normal-100sin(30°), solve for Normal force=+69.6 N (+y), so frictional force $F_{kinetic\ friction}=\mu_k N$=6.96N in +x-direction, since mass moves -x

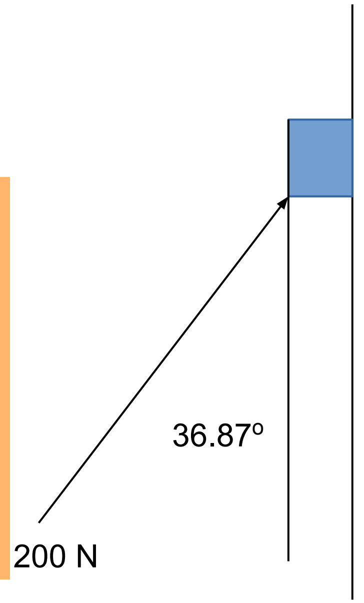
Now write: $\Sigma f_x=ma_x$ => (2kg)a_x=-100Ncos(30°)+ 6.96N, solve for a_x=-39.82 m/s^2, now solve for $v_f=v_i+at$, since v_i=0, and t=4 s, v_f(t=4s)=-159.28 m/s, and also solve for displacement=$x_f-x_i=v_{ix}t+ ½a_xt^2$= ½ (-39.82)*16=318.6 m

Now check using Work-energy approach: W_{tot}= ½(2kg)($v_f^2-v_i^2$)=25370 J, we now add the work done by each individual force and verify that that sums to 25370 J. $W_{gravity}$=0 since gravity (-y) perpendicular to displacement (-x); similarly, W_{Normal}=0; $W_{friction}$=6.96N*318.6m*$\cos\theta_{F,d}$, angle=180 degrees so $\cos\theta_{F,d}$=-1. W_{100N}=100N*318.6m*cos(30°) since force vector at 30 degrees wrt displacement.

So: 100*318.6*0.866-6.96*318.6=25373 J (checks out!)

In the problem below, calculate **displacement** and **v_f** using F=ma, then check your answers using $W_{tot}=\Delta KE=\Sigma W_i$; with W_i the work done by each force i ($W_i=|F_i||\text{displacement}|\cos\theta_{F,d}$) as the mass moves over the distance d

Given: $\mu_k=0.2$; $v_i=0$ m/s, t=2s, m=5 kg



Solve for a, using $\Sigma f_x=ma_x$, and $\Sigma f_y=ma_y$; in x-direction, $a_x=0$, so $0=-\text{Normal}+200\sin(36.87^o)$, solve for Normal force=-120 N (-x), so frictional force $F_{\text{kinetic friction}}=\mu_k N=24$ N in -y-direction, since mass moves -y
Now write: $\Sigma f_y=may$ => $(5kg)a_y=-5*9.8+200N\cos(36.87^o)-24N$, solve for $a_y=+17.4$ m/s^2, now solve for $v_f=v_i+at$, since $v_i=0$, and t=2 s, $v_{f,y}(t=2s)=+34.4$ m/s, and also solve for displacement$=y_f-y_i=v_{iy}t+ ½a_y t^2= ½(17.4)*4=34.8$ m

Now check using Work-energy approach: $W_{tot}= ½(5kg)(v_f^2-v_i^2)=3027.6$ J, we now add the work done by each individual force and verify that that sums to 3027.6 J. $W_{gravity}=49N*34.8m*\cos\theta_{F,d}$, angle=180 degrees so $\cos\theta_{F,d}=-1$ since gravity (-y) opposite displacement (+y), so $W_{grav}=-1705.2J$; $W_{friction}=24*34.8*\cos\theta_{F,d}$; cosine again = 1, so $W_{friction}=-835.2$ J; $W_{200N}=200N*34.8*\cos(36.87^o)=5568$ J since force vector at 36.87 degrees wrt displacement.
So: 5568-1705.2-835.2=3027.6 J (checks out!)

Comment on Work and heat:
To take into account conservative and non-conservative forces, can consider work done by an external force going into change in PE, change in KE and heat, or:

$$W_{ext} = \Delta PE + \Delta KE + |E_{heat}|$$

UHECR14 and hotspots detected via nitrogen fluorescence. Relative energy comparable to M&M accelerated to equivalent energy of Hummer (M=3900 kg) moving at Mach 1

The 4 kg Laika, la perra maravilla, slides down a rough 36.87° incline with a base of 80 m along the ground, with v_i=10 m/s. At the bottom of the incline, Laika has velocity v_f=12 m/s. The magnitude of heat energy generated by friction as Laika slides (equal to the magnitude of frictional work) is:

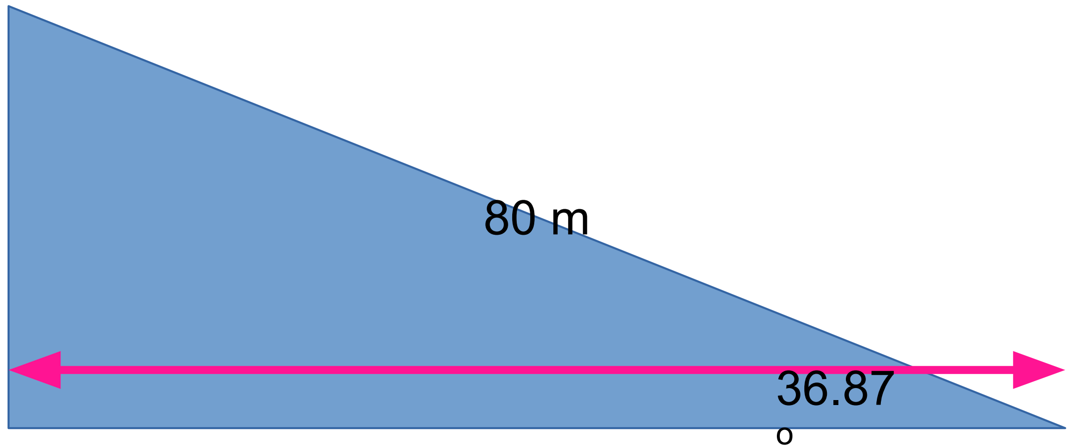
A) 240 J

B) 1132 J

C) 2264 J

D) 4622 J

E) NOTA



In the previous problem, the coefficient of kinetic friction is:

A) 0.14

B) 0.28

C) 0.56

D) 0.72

E) NOTA

In the previous problem, how long does it take Laika to slide from the top to the bottom of the incline assuming she slides with constant acceleration? (use $W_{net}=(\Delta KE)=ma_{net}$ x d)

A) 1 s

B) 9.09 s

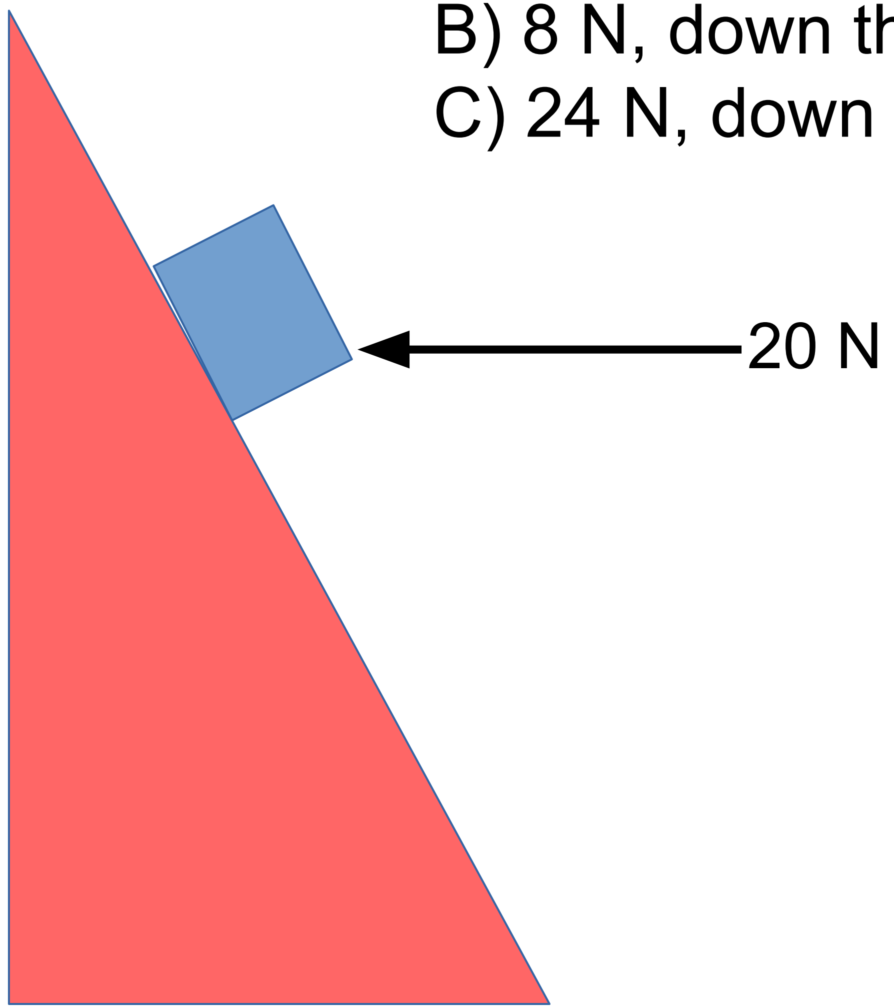
C) 18.18 s

D) 4.545 s

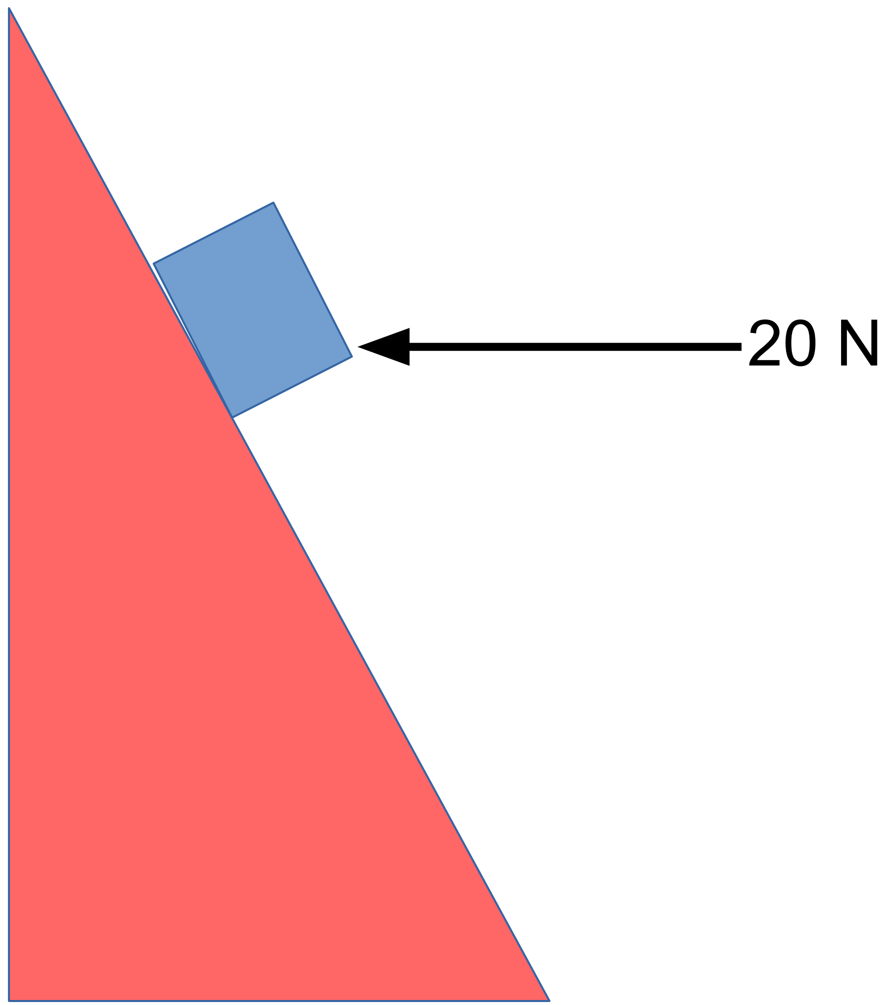
E) NOTA

Given the external force shown, the magnitude of the net force acting on the 2 kg mass shown is about (assuming no friction)

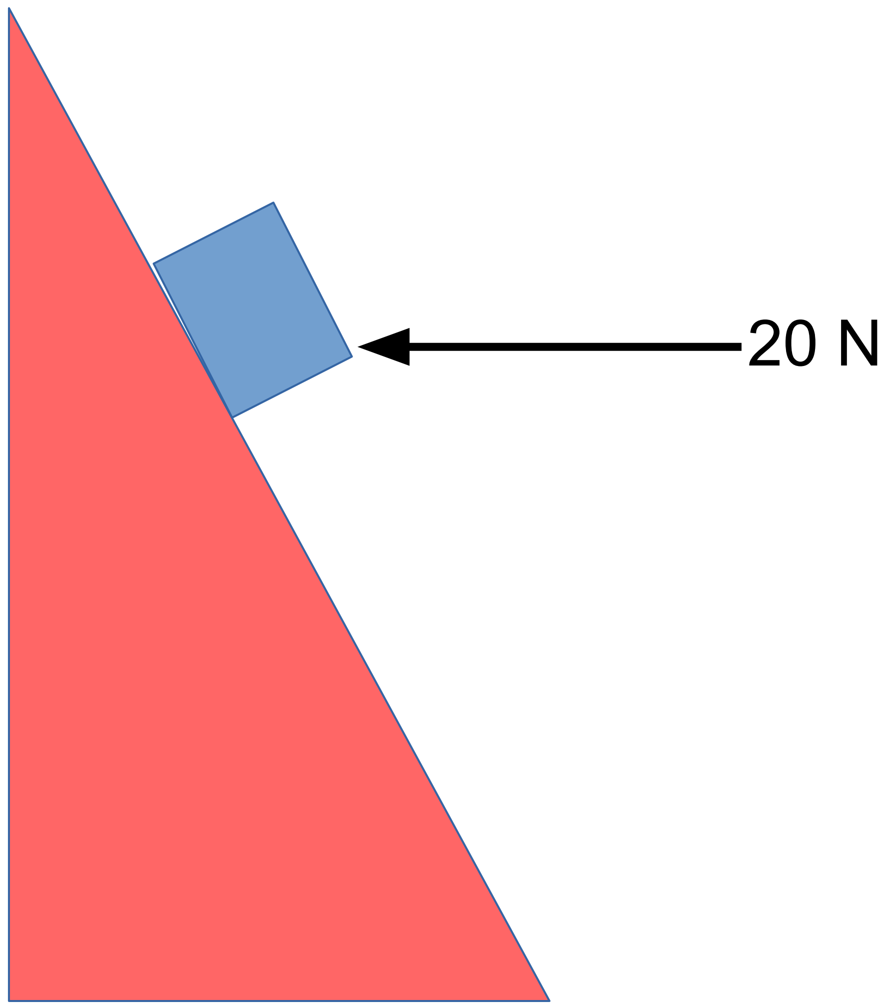
A) 16 N, up the incline
B) 8 N, down the incline
C) 24 N, down the incline



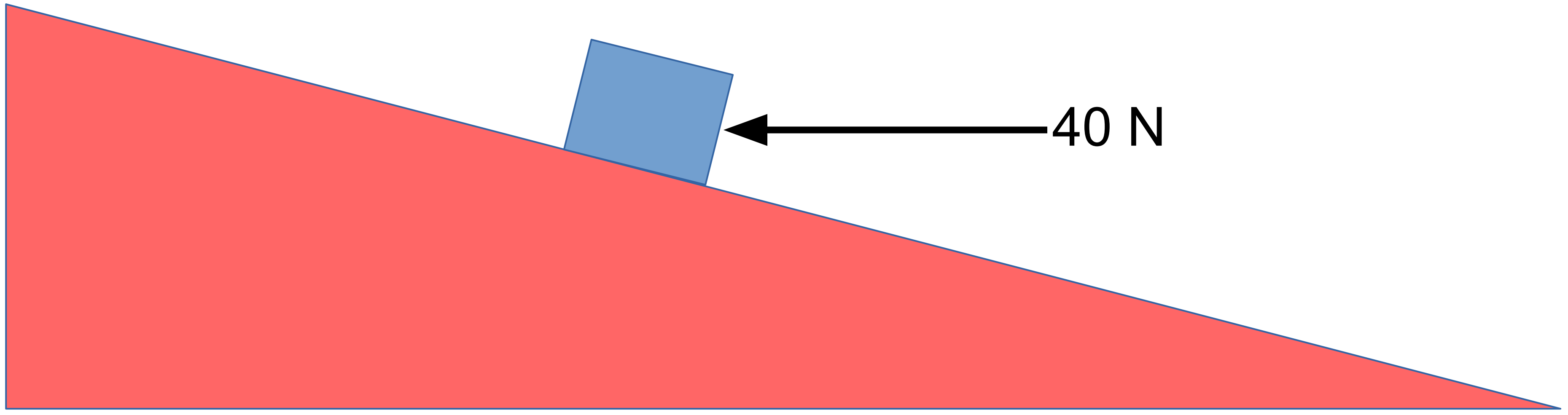
From your previous answer, estimate the total work done on the 2 kg mass after 3 seconds, by determining the total distance traveled over 3 seconds, using the acceleration estimated from your net force, and also using $W_{tot}=|F_{net}||d|\cos\theta_{F(net),d}$



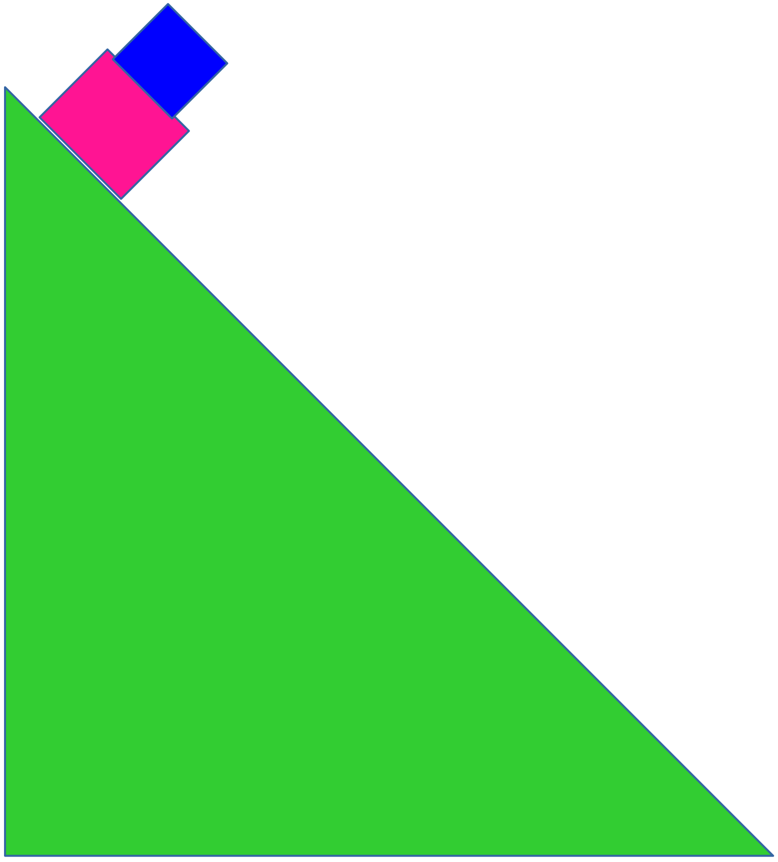
Since you now have both acceleration and the work done, you can determine v_f in two ways. Check that those both give:



Given the external force shown, estimate the velocity of the 2 kg mass after 3 seconds, given that the surface is frictionless



Two boxes are stacked on top of each other on a rough incline, sliding down the incline, from the top. By the bottom of the incline, they have come to rest. For the top box, identify each force acting on the box, and indicate whether that force does positive/negative/zero work



A 2 kg ball with y_i=20m is thrown off a cliff with |v|=10 m/s at an angle of 60º wrt horizontal. (*We'll do this in steps: first solve for y_f, $v_{y,f}$, and $v_{x,f}$ at t=3 s using kinematics-only, then calculate $|v_f|$ using energy conservation, and check that $|v_f|=sqrt(v_{x,f}^2+v_{y,f}^2)$ calculated from kinematics.*) 1. What is the final y-position of the ball at t=3 s?

A) 8.66 m

B) 5 m

C) 10 m

D) 1.88 m

E) NOTA

A 2 kg ball with y_i=20m is thrown off a cliff with |v|=10 m/s at an angle of 60º wrt horizontal. What is the velocity of the ball at a time t=3s? (*We'll do this in steps: first solve for y_f, $v_{y,f}$, and $v_{x,f}$ at t=3 s using kinematics-only, then calculate $|v_f|$ using energy conservation, and check that $|v_f|=\mathrm{sqrt}(v_{x,f}^2+v_{y,f}^2)$ calculated from kinematics.*) 2. What are $v_{f,x}$ and $v_{f,y}$ at t=3 s?

A) 10 m/s, -6 m/s
B) 5 m/s, 8.66 m/s
C) 5 m/s, -20.74 m/s
D) 8 m/s, 21.33 m/s
E) NOTA

A 2 kg ball with y_i=20m is thrown off a cliff with |v|=10 m/s at an angle of 60º wrt horizontal. What is the velocity of the ball at a time t=3s? (*We'll do this in steps: first solve for y_f, $v_{y,f}$, and $v_{x,f}$ at t=3 s using kinematics-only, then calculate $|v_f|$ using energy conservation, and check that $|v_f|=sqrt(v_{x,f}^2+v_{y,f}^2)$ calculated from kinematics.*) 3. What is the final velocity at t=3 s?

A) 21.33 m/s
B) 20.74 m/s
C) 8.66 m/s
D) 5 m/s
E) NOTA

A 2 kg ball with y_i=20m is thrown off a cliff with |v|=10 m/s at an angle of 60º wrt horizontal. After solving for y_f, $v_{y,f}$, and $v_{x,f}$ at t=3 s using kinematics-only, check for $|v_f|$ using energy conservation, and check that $|v_f|=\text{sqrt}(v_{x,f}^2+v_{y,f}^2)$ calculated from kinematics. Does your answer depend on the mass of the ball?

A) $y_f=y_i+v_{i,y}t+ ½a_yt^2$; acceleration=gravity (-9.8 m/s^2), so y_f=+*1.88 m*. v_{ix}=10m/s*cos60=+*5m/s*; $v_{i,y}$=10m/s*sin60=+*8.66m/s*; $v_{f,x}=v_{i,x}+a_xt=v_{i,x}$ since a_x=0. In y-direction, $v_{f,y}=v_{i,y}+a_yt$, but a_y=-9.8 m/s^2, so $v_{f,y}$=-20.74 m/s. So, from kinematics, we expect |v|=sqrt(20.74*20.74+5*5)=**21.33 m/s**

B) now check |v| using energy conservation. No push or pull on ball, so we can use $PE_i+KE_i=PE_f+KE_f$. Potential energy PE=m|g|h, so:

C) m|g|*20m+ ½mv_i^2=m|g|(+1.88m)+ ½mv_f^2; v_i=10 m/s (note that components don't matter here), and we can cancel the common mass m term, solving for v_f =sqrt(2*43.6*9.8+100)=**21.33 m/s**

D) =>two numbers match!

A 2 kg ball with y_i=20m is thrown off a cliff with |v|=10 m/s at an angle of 60º wrt horizontal. After solving for y_f, $v_{y,f}$, and $v_{x,f}$ at t=4 s using kinematics-only, check for $|v_f|$ using energy conservation, and check that $|v_f|=\text{sqrt}(v_{x,f}^2+v_{y,f}^2)$ calculated from kinematics. Does your answer depend on the mass of the ball?

A) $y_f=y_i+v_{i,y}t+ ½a_yt^2$; acceleration=gravity (-9.8 m/s^2), so y_f=*-23.6 m*. v_{ix}=10m/s*cos60=+*5m/s*; $v_{i,y}$=10m/s*sin60=+*8.66m/s*; $v_{f,x}=v_{i,x}+a_xt=v_{i,x}$ since a_x=0. In y-direction, $v_{f,y}=v_{i,y}+a_yt$, but a_y=-9.8 m/s^2, so $v_{f,y}$=-30.54 m/s. So, from kinematics, we expect |v|=sqrt(30.54*30.54+5*5)=**30.95 m/s**

B) now check |v| using energy conservation. No push or pull on ball, so we can use $PE_i+KE_i=PE_f+KE_f$. Potential energy PE=m|g|h, so:

C) m|g|*20m+ $½mv_i^2$=m|g|(-23.6m)+ $½mv_f^2$; v_i=10 m/s (note that components don't matter here), and we can cancel the common mass m term, solving for v_f =sqrt(2*43.6*9.8+100)=**30.90 m/s**

D) =>two numbers match!

A 2 kg mass, with v_i=4 m/s, slows to zero on a frictionless table by compressing a spring with constant k=200 N/m. Determine the compression of the spring.

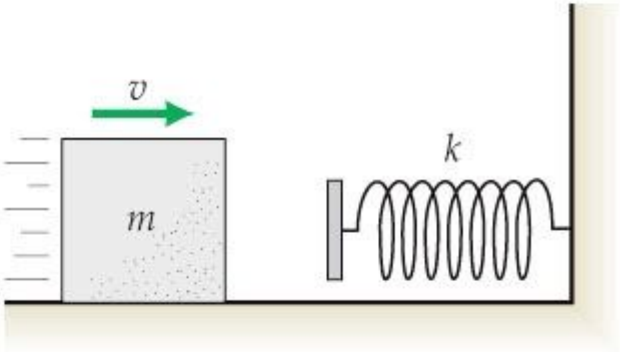
A) 10 cm

B) 40 cm

C) 1 m

D) 4 m

E) NOTA



A metal ball, having mass 2 kg is fired horizontally from a spring H=2 m off the ground with k=2000 N/m compressed 10 cm. The floor impact velocity is:

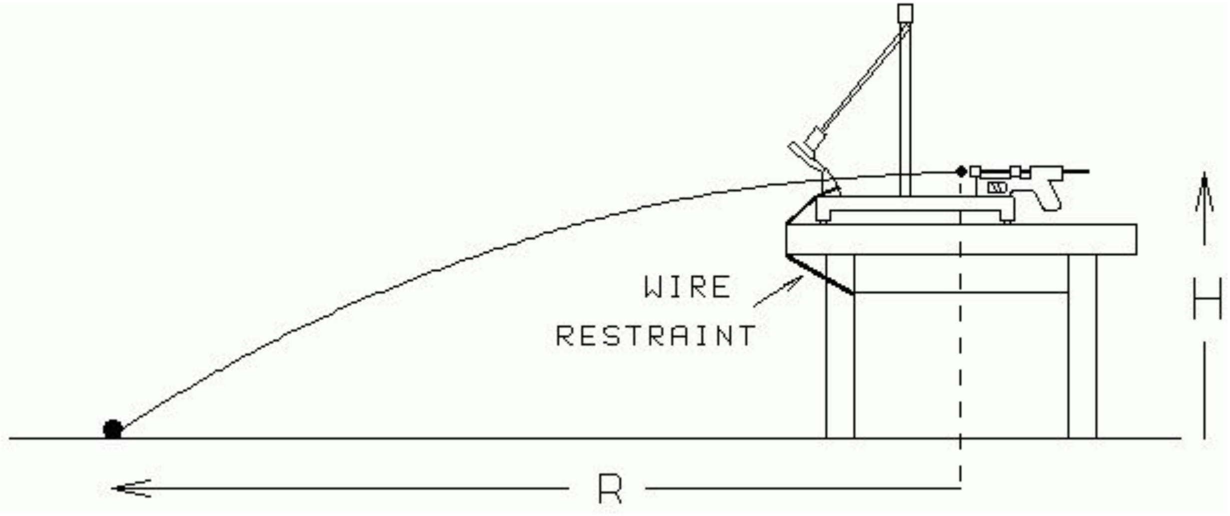
A) 3.16 m/s

B) 6.26 m/s

C) 7.01 m/s

D) 9.8 m/s

E) NOTA



A 100 g ball compresses a spring (k=2000 N/cm) 2 cm, making an angle of 55^{o} relative to the vertical. If 20% of the initial spring PE is lost as heat, find the velocity of the ball on impact with the ground.

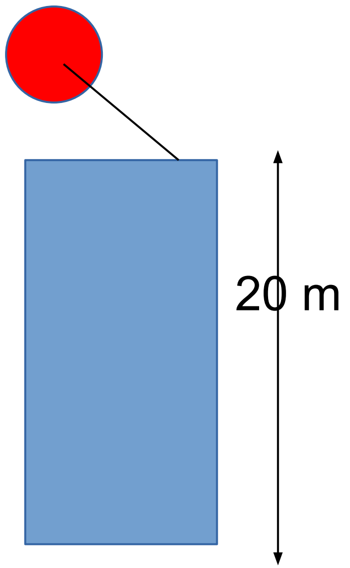
Problem is direct application of E conservation. Ball initially at rest, so (with 80% of initial PE of spring not lost to heat):

$0.8*PE_{spring}+PE_{grav}=KE_f+PE_f$; final PE=0, so: $0.8*0.5*200000*0.02*0.02 + 0.1*9.8*20=0.5*0.1*v^2$; solve for velocity=32.12 m/s.

As spring uncoils: $W_{grav}<0$; $W_{spring}>0$

As mass ascends: $W_{grav}<0$

As mass descends: $W_{grav}>0$



Imagine that the mass on the spring were fired vertically rather than horizontally. In that case, the final velocity, on impact would be:

A) Larger than if fired horizontally

B) Smaller than if fired horizontally

C) The same

After hitting the floor, the mass now slides across the floor and comes to a stop. Which statement is true?

A) The time to come to a stop depends on μ_K

B) The heat generated, in the process of coming to a stop, depends on μ_K

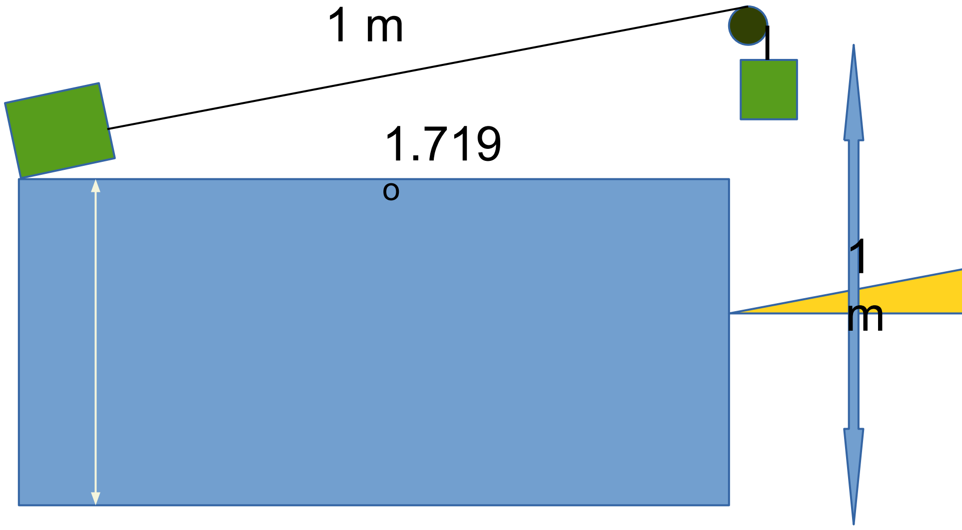
C) $W_{friction,\ total}$ is independent of μ_K

D) Two of the above are true

E) All of the above are true.

(M15) Mass m_1=1 kg is on the incline and m_2=0.2 kg hangs from the pulley; what is the impact velocity of m_2 after being dropped from rest if the incline is frictionless (i.e., heat=0).

A) 1.25 m/s B) 1.66 m/s C) 2.5 m/s D) 5 m/s E) NOTA



Write the equation you would use to solve for the tension in the top string.

Which statement is true?

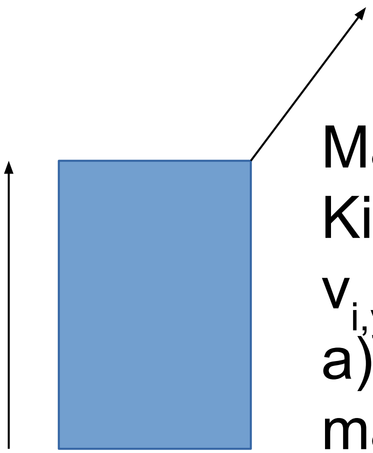
A) As PE_2 increases, PE_1 decreases

B) As KE_2 increases, KE_1 increases

C) Both A) and B)

D) Neither A) nor B)

A) Find v_f from a) kinematics and b) Energy conserv.



Mass of ball=4kg.
Kinematics: $x_f=x_i+v_{i,x}t+\frac{1}{2}a_xt^2$; $y_f=y_i+v_{i,x}t+\frac{1}{2}a_yt^2$; $v_{i,x}=12$ m/s; $v_{i,y}=16$ m/s. To solve, break the problem up into two parts: part a): mass goes up from initial height of 100 m, reaches maximum height and gets back to h=100 m, going downwards. Part b) mass then goes from height of 100 m to height=0 m. At the end of part a), ball is moving down at 20 m/s, making angle of 53.13^o wrt x. So we only need to find the added velocity as ball goes from y=100m→y=0m. Use: $0m=100m-(16m/s)t-4.9t^2$, solve for time=3.17 s=>$v_{f,y}$=-16m/s–3.17*9.8=- 47m/s; the net velocity is sqrt(-47*-47+12*12)=48.5 m/s

Now check with energy techniques:
$PE_i+KE_i=PE_f+KE_f$=>4|g|*100+0.5*4*400=0.5*4*v_f^2 (note that mass of 4 kg cancels in equation for final velocity), solve: v_f=48.6 m/s (checks out!)

A 4kg mass, moving on a rough floor with v_i=+8 m/s, slides into a spring and comes to rest after traveling 2 m. If μ_K=0.2, determine the spring constant.

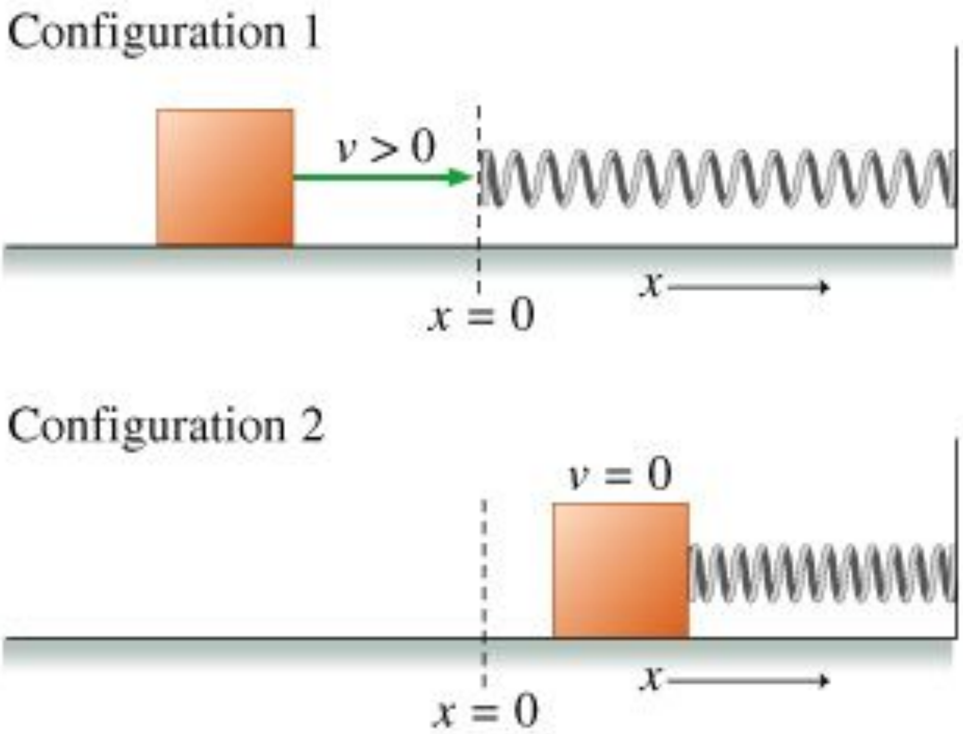
A) 7.5 N/m

B) 56.16 N/m

C) 9.8 N/m

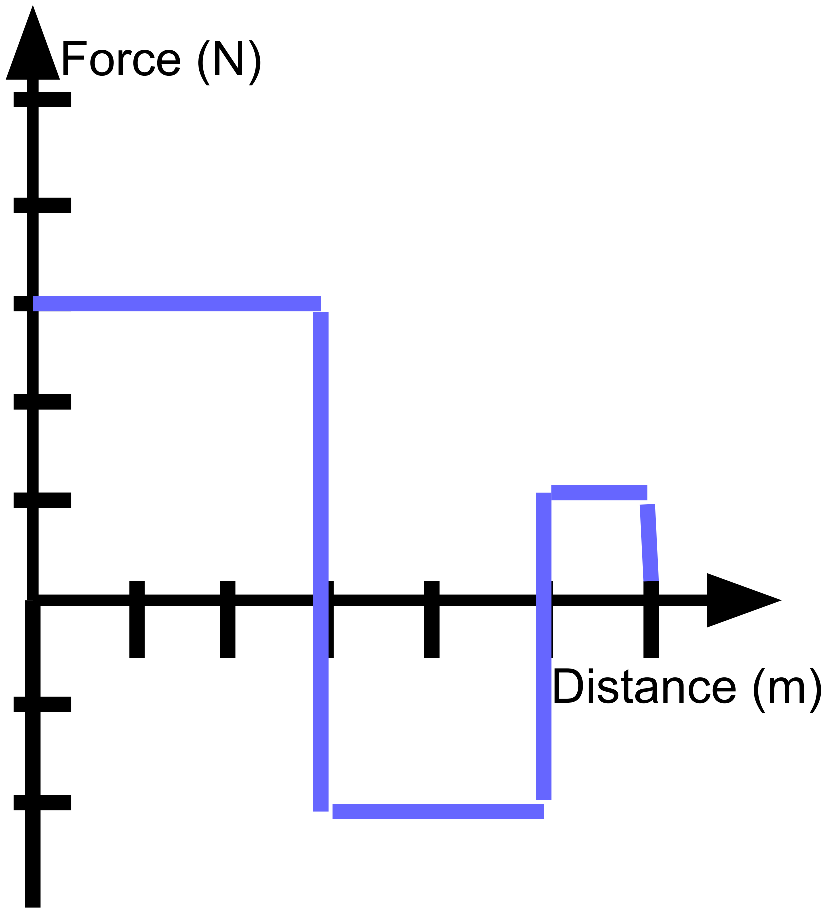
D) 2 N/m

E) NOTA

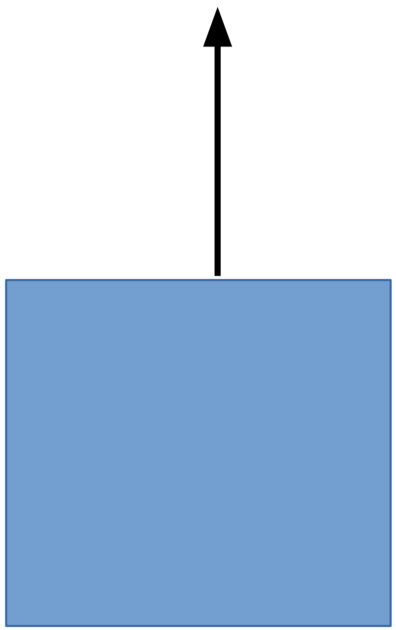


A 2 kg box is acted upon by Laika, Das Wunder Hund as a function of distance. Based on the translation of v(t) graphs into Δx, then, if $v_i(x=0m)=+2$ m/s, what is the $v_f(x=6m)$?

A) 2 m/s
B) -2 m/s
C) 3.16 m/s
D) 4 m/s
E) NOTA



A 4 kg elevator is pulled up by a cable with |T|=100 N. The average cable power over 4 seconds is:



A) 158 Watts

B) 860 Watts

C) 1540 Watts

D) 3040 Watts

E) NOTA

Laika's metabolism is closest to: (useful info: microwave=1500 W, Plasma TV=Espresso Machine=350 W, Laika consumes ~1000 kCal/day; 1 calorie=4.184 Joules; 1 day=86400 seconds)

A) 50 W

B) 200 W

C) 400 W

D) 800 W

E) 1200 W

Energy Transfer and Radiation (Ch. 14)

Key points: $I_{Solar} = 1340\ W/m^2$

$$\Delta Q/\Delta t = \sigma \varepsilon A(T_H^4 - T_L^4);$$

$\sigma = 5.67\times10^{-8} J/s\cdot m^2\cdot K^4$ is the Stefan-Boltzmann constant

ε = *"emissivity" (material-dependent)*

Laika sunbathes on Lake Harriet. How much solar energy does he absorb in one minute, at 6 pm, when the sun is 30° above the horizon? Laika's dimensions, lying down and in the sun, are 10 x 60 cm (W_0=1368 W/m^2). http://www.youtube.com/watch?v=nhW7MJh_FR4

A) 2462 J B) 4177 J

C) 1278 J D) 443 J

E) NOTA

The intensity of a spherically spreading EM wave 2m from the source is 4 W/m^2; the amplitude is 4 m. At a distance 8m from the source, the Amplitude and Intensity are, respectively:

A) 4 m, 4 W/m^2

B) 2 m, 4 W/m^2

C) 2 m, 1 W/m^2

D) 1 m, 0.25 W/m^2

E) NOTA

Energy spreading in a 10-dimensional spacetime manifold would have a distance dependence that varies as

A) $1/r^2$

B) $1/r^4$

C) $1/r^{11}$

D) $1/r^{10}$

E) $1/r^9$

The solar *intensity* at the Earth's surface is 1368 W/m^2. Based on that, the total output power at the Sun is ($d_{Earth,Sun}$ ~149.6 x 10^6 km) :

A) 2.57 x 10^{15} Watts

B) 3.84 x 10^{26} Watts

C) 1.33 x 10^9 Watts

D) 2.66 x 10^9 Watts

E) NOTA

The solar energy absorbed by a 2m tall x 40 cm across person directly facing the sun, in one hour (assuming 100% efficiency) is about:

A) 4 Million Joules
B) 2000 Joules
C) 20000 Joules
D) 100 Joules
E) 8000 Joules

Heat spreads in 3-dimensions. At a distance of 2 m from the source, the heat intensity is 4 W/m^2. What is the intensity at a distance of 1 m?

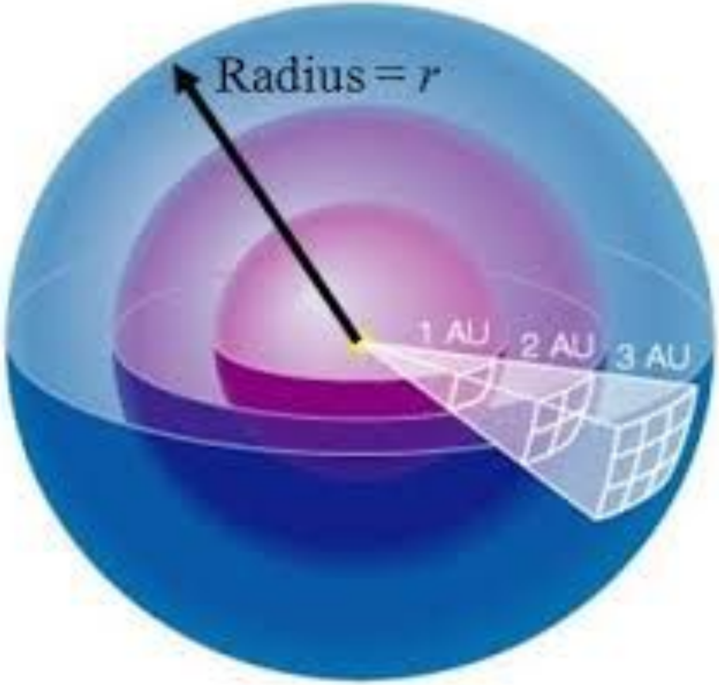
A) 4 W/m^2

B) 8 W/m^2

C) 16 W/m^2

D) 0.25 W/m^2

E) NOTA



Given that Intensity= $Power_{source}$/Area-over-which-power-is-spread, what is the source power in the previous problem, assuming spherical spreading?

A) 16 W

B) 16π W

C) 64 W

D) 64π W

E) NOTA

Suppose you measure I(2m)=8 W/m^2, and are told that heat is not spreading spherically, but confined to a tunnel. In that case, I(1m)=

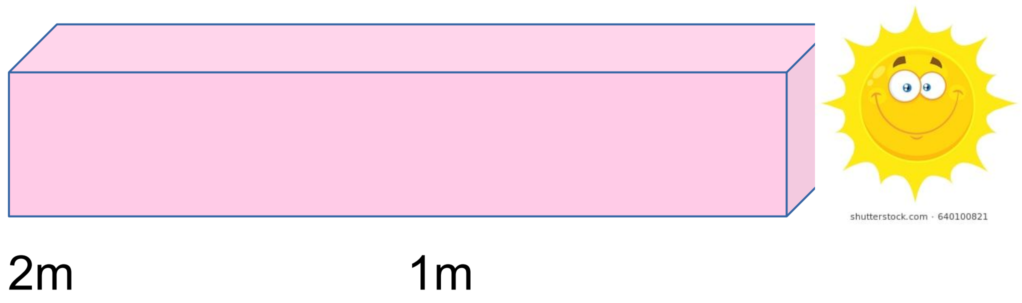
A) 4 W/m^2

B) 8 W/m^2

C) 16 W/m^2

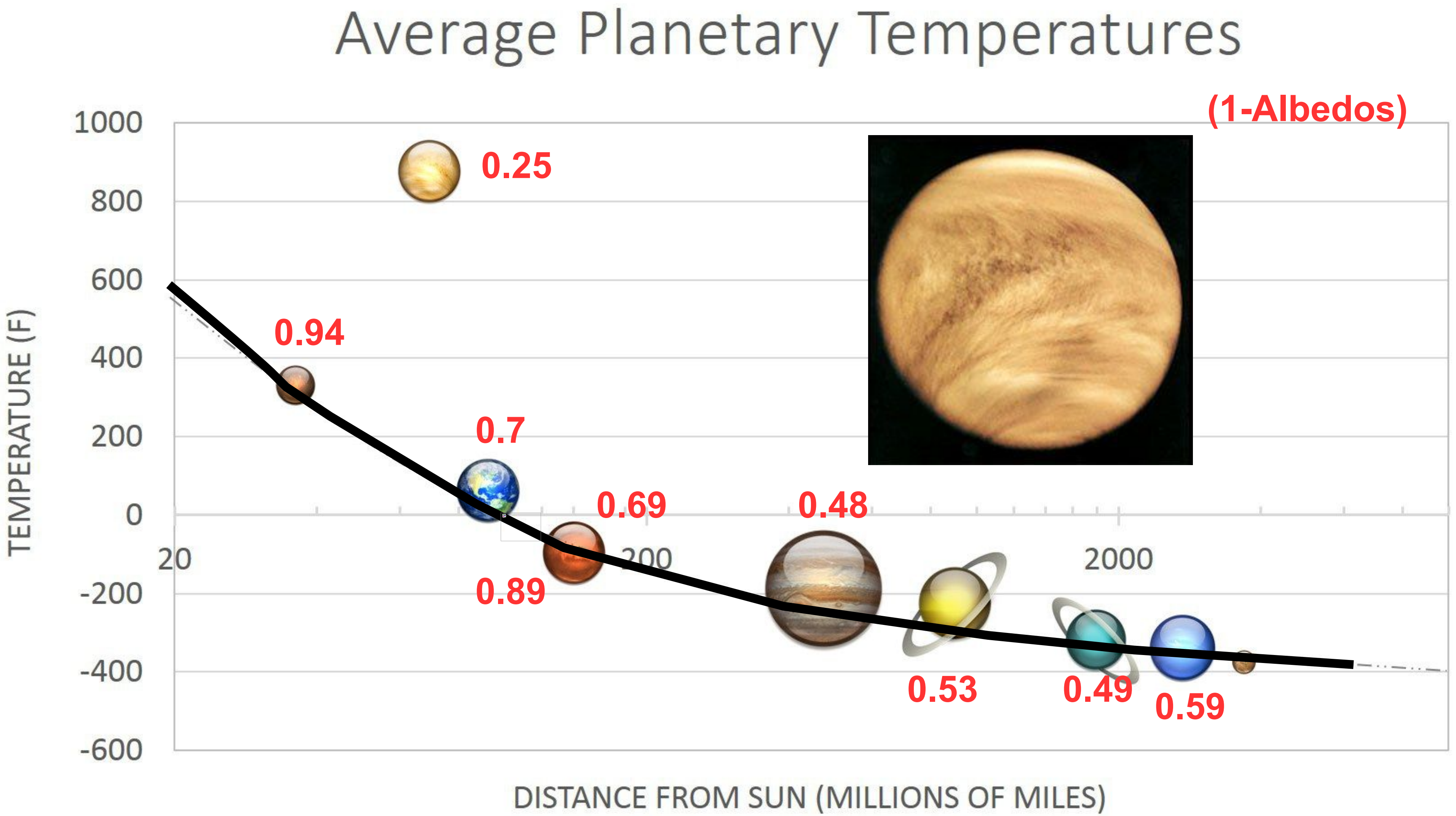
D) 0.25 W/m^2

E) NOTA



Planet Temperatures: a) distance to sun, b) “albedo”, c) greenhouse effect

http://www.climatefiles.com/climate-change-evidence/presidents-report-atmospher-carbon-dioxide/



- Without CO_2 + CH_4 + N_2O warming, Earth surface temperature would be ~0 F / -18 C (giss.nasa.gov)


GLOBAL WARMING READY
DIESEL


GLOBAL WARMING READY
DIESEL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GLOBAL WARMING READY
DIESEL

Ch. 8: 8.1-8.8 Momentum: $\vec{F}=\Delta\vec{p}/\Delta t$ Equivalent to laws of physics being invariant under translation.

No external forces=>momentum cons.

Two types of reactions:

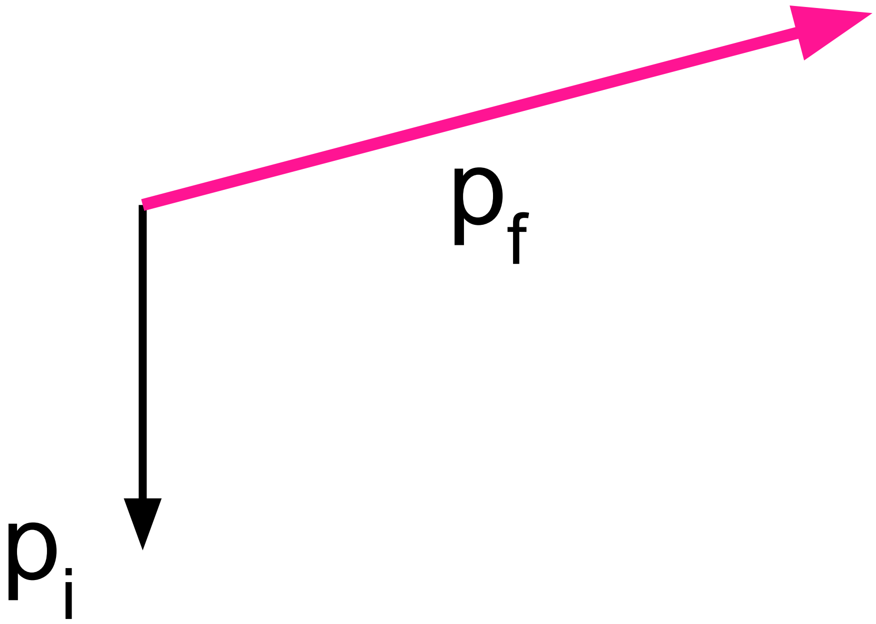
1) Elastic collisions (billiard ball): momentum and KE conserved. For two-body: $v_{f,1}-v_{f,2}=v_{i,2}-v_{i,1}$

2) Inelastic collisions (colliding clay): momentum conserved, loss of kinetic energy shows up as heat

$$v_{f1}=\frac{(m_1-m_2)v_{i1}}{m_1+m_2}$$

$$v_{f2}=\frac{2m_1v_{i1}}{m_1+m_2}$$

A 4 kg mass, with v_i=4 m/s is acted on by some force $F_{contact}$. If $\mathbf{p_f}$ is drawn to scale, estimate $|\mathbf{F_{contact}}|$, neglecting gravity, if $\mathbf{p_i} \rightarrow \mathbf{p_f}$ in 4 seconds.



A) 10 N

B) 40 N

C) 160 N

D) 1800 N

E) NOTA

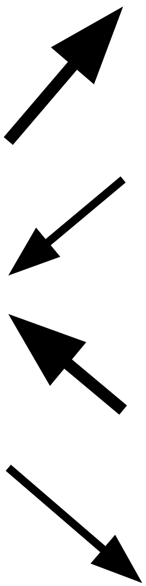
A 4 kg mass has v_i=4 m/s. If $\mathbf{p_f}$ is drawn to scale, in which direction does $\mathbf{F_{contact}}$ point (again neglecting gravity)?

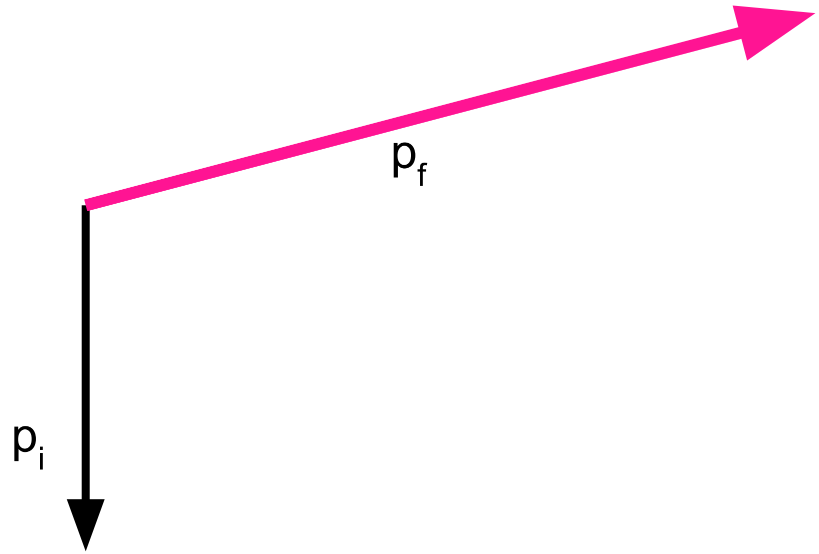
A)

B)

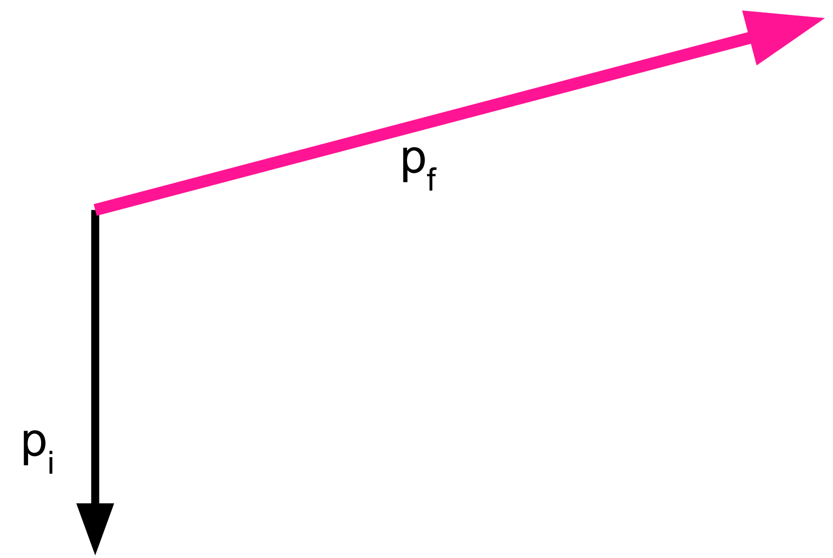
C)

D)





A 4 kg mass has v_i=4 m/s. If $\mathbf{p_f}$ is drawn to scale, how does your answer for $\mathbf{F_{contact}}$ change, now including gravity, if the force is applied over 1 second rather than 4 seconds. ($\Sigma\mathbf{F}_i = m\mathbf{a} = (\mathbf{p_f} - \mathbf{p_i})/\Delta t$)



A) The external force would be more vertical

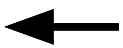
B) The external force would be more horizontal

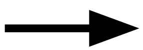
C) The external force would be the same as before

A 2kg mass is moving at 8 m/s at +45° wrt +x. Laika, cudowną karma dla psów exerts a force on it for 4 seconds, after which it is moving in the -y direction with |v|=5.66 m/s. Ignoring gravity, the components of the force exerted by Laika are about:

A) F_x=2.8 N; F_y=5.6 N
B) F_x=-2.8 N; F_y=+5.6 N
C) F_x=-2.8 N; F_y=-5.6 N
D) F_x=2.8 N; F_y=-5.6 N

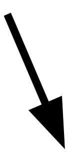
A 2kg mass is moving at 8 m/s at $+45^{o}$ wrt +x. Laika, cudowną karma dla psów exerts a force on it for 4 seconds, after which it is moving in the -y direction with $|v|=5.66$ m/s. What is the direction of the force exerted by Laika?

A) 

B) 

C) 

D) 

E) 

A 4 kg ball is in the air, with $\mathbf{v}_i$=2 m/s, at -30° wrt +y. F_{ext} acts for 0.2 seconds, after which the mass has $\mathbf{v}_f$=4 m/s, at +80° wrt -y. Including the effect of gravity, then, from graphical addition, the magnitude of F_{ext} ~

A) 20 N

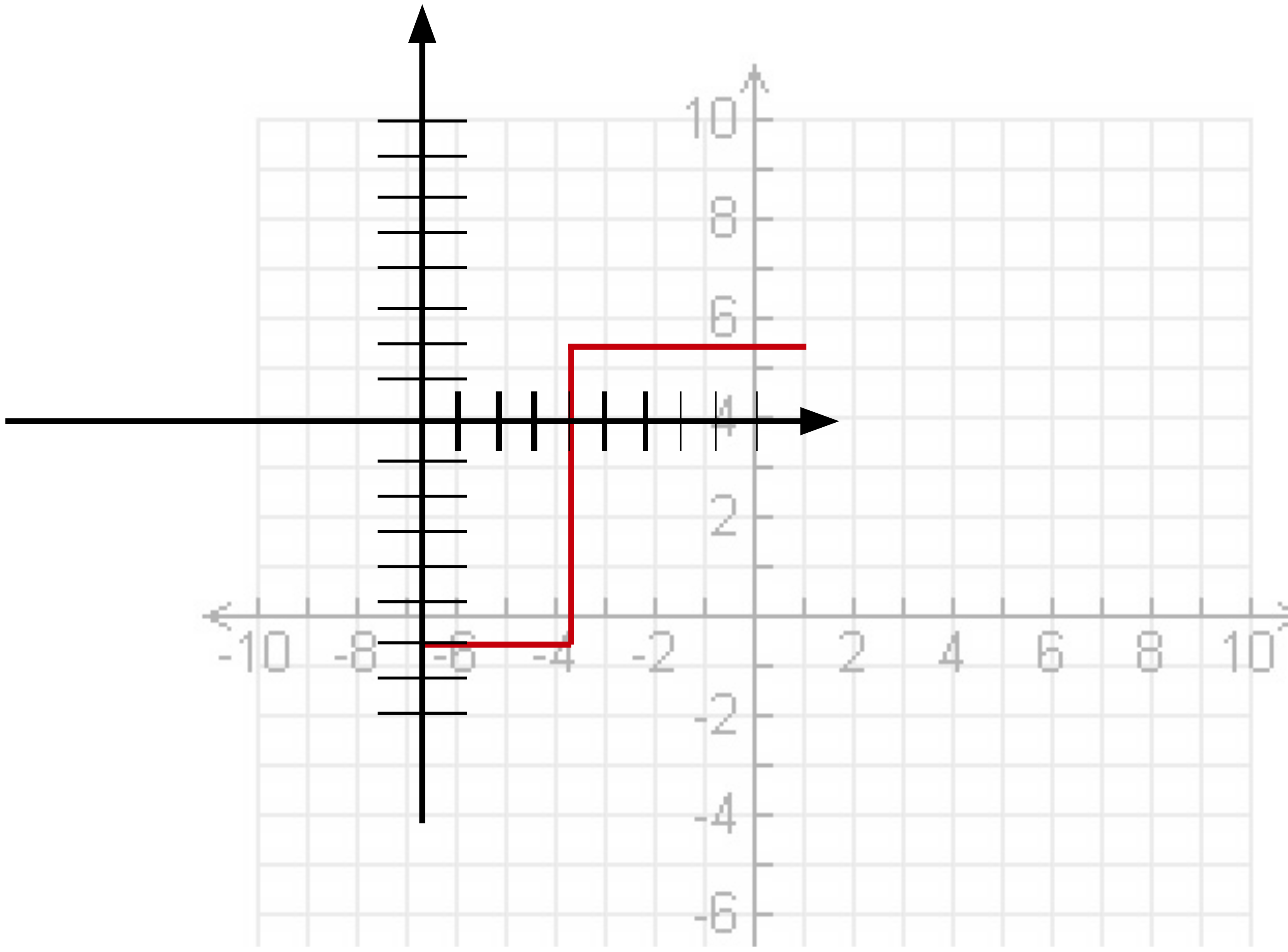
B) 65 N

C) 130 N

D) 180 N

A 3 kg mass, moving with $v_{x,i}$=-4 m/s initially, is acted upon by the force F_x shown,
as a function of time. What is the velocity after 10 s?

A) 0 m/s B) -4 m/s C) -8 m/s D) 4 m/s E) NOTA



Kev, 117 kg, and running at 5 m/s in the +x-direction, and Mattie, 83 kg, and running at 8 m/s in the -y-direction, embrace, after a long separation. Arm-in-arm, they now run together, at a velocity of:*

A) 17 m/s

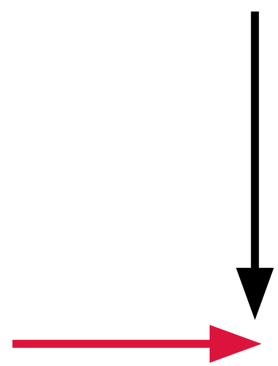
B) 13.3 m/s

C) 4.4 m/s

D) 8.5 m/s

E) NOTA

Disclaimer: This problem is in no manner intended to replicate, duplicate, or depict events, real of fictional, that might otherwise be construed or interpreted as representative of the viewpoints of this great University of Kansas, the Chancellor of this great University of Kansas, the Governor of this great State of Kansas, and/or the living and/or deceased descendents of John Steuart Curry, Ameila Earhardt, Dwight David Eisenhower, Kerry Livgren, Gordon Parks, Laika, the wonder dog, Kelli McCarty, Candy Loving, John Nichols, Buster Keaton, the Hon. Kris Kobach, in excelsio dei, and/or any other individuals and/or their progeny who may or may not be otherwise responsible for running this great state into the great ground.



The heat generated in the collision is

A) 620 J

B) 1355 J

C) 2165 J

D) 3260 J

E) 5540 J

If Matty were moving in the -x-direction, the heat generated would:

A) Increase

B) Decrease

C) Be unchanged

A 3 kg mass moving with |v|=3 m/s along the +x-axis collides **inelastically** at the origin with a 4 kg mass moving with |v|=4 m/s at an angle of 120° with respect to +x (i.e., -60° wrt -x) . What are the velocity components of the final composite object?

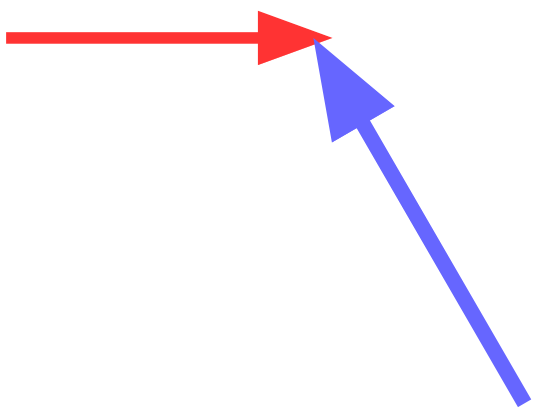
A) $v_{f,x}$=2.43 m/s, $v_{f,y}$=-1.12 m/s

B) $v_{f,x}$=-0.143 m/s, $v_{f,y}$=+1.979 m/s

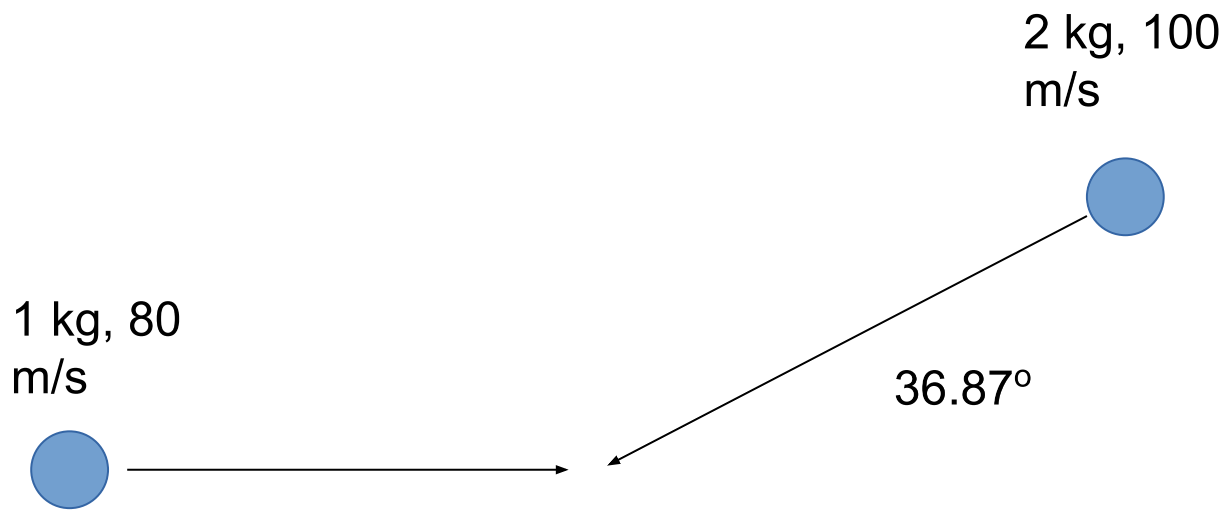
C) $v_{f,x}$=2.43 m/s, $v_{f,y}$=+1.12 m/s

D) $v_{f,x}$=0.143 m/s, $v_{f,y}$=1.979 m/s

E) NOTA



Given the inelastic collision shown, the final velocity components are:



A) 40 m/s, 30 m/s

B) 0 m/s, 20 m/s

C) 20 m/s, 0 m/s

D) -26.7 m/s, -40 m/s

E) NOTA

In the previous problem, how much heat is generated in the collision?

A) 9792 J

B) 1425 J

C) 3172 J

D) 6342 J

E) NOTA

A 10 gram bullet moving vertically at v_i=200 m/s (just before collision) is absorbed by a stationary 490-gram piece of balsa wood which then flies vertically upwards to some height h. How much heat energy is generated in the initial collision?

A) 46 J

B) 100 J

C) 2000 J

D) 196 J

E) NOTA

https://www.youtube.com/watch?v=I8piMHsOya4

A 10 gram bullet moving vertically at v_i=200 m/s is absorbed by a 490-gram piece of balsa wood; how high does the bullet+wood combination go into the air?

A) 2 m B) 20 m C) 1.625 m D) 0.816 m E) NOTA

https://www.youtube.com/watch?v=I8piMHsOya4

Between the time when the bullet is initially fired and the bullet+balsa comes to rest, which of the following quantities are conserved?

A) Momentum of the bullet
B) KE of the bullet
C) Momentum of the bullet+balsa
D) Two or more of the above
E) None of the above

`Inverse' of inelastic collision

A 12 kg mass, moving with v=+5 m/s along +x, splits into two fragments; one 4 kg fragment has $v_{f,y}$=-2 m/s and $v_{f,x}$=-4 m/s. $v_{f,x}$ and $v_{f,y}$ of the 8 kg fragment are:

A) +9.5 m/s, +1 m/s

B) +9.5 m/s, -1 m/s

C) -9.5 m/s, -1 m/s

D) -9.5 m/s, +1 m/s

E) NOTA

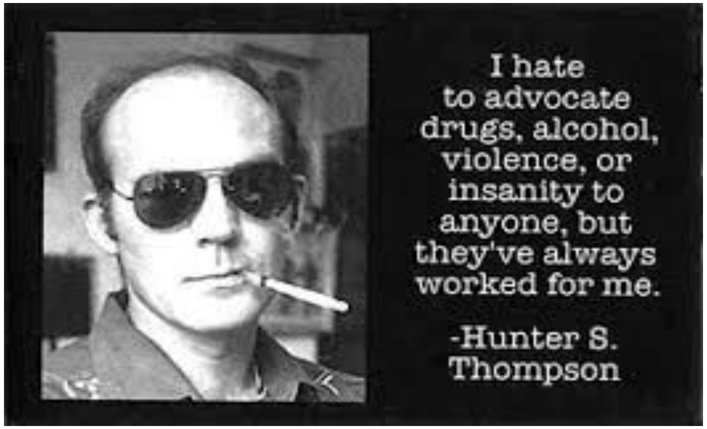
A 3400 kg cannon is mounted so that it can recoil freely horizontally. When Hunter Thompson (50 kg), undrar mannen, is shot out of the cannon, which of the following statements is true regarding the system consisting of Hunter Thompson and the cannon (neglect the effect of static friction)? *(Consider: Is the reaction the same as if it were in outer space?)*

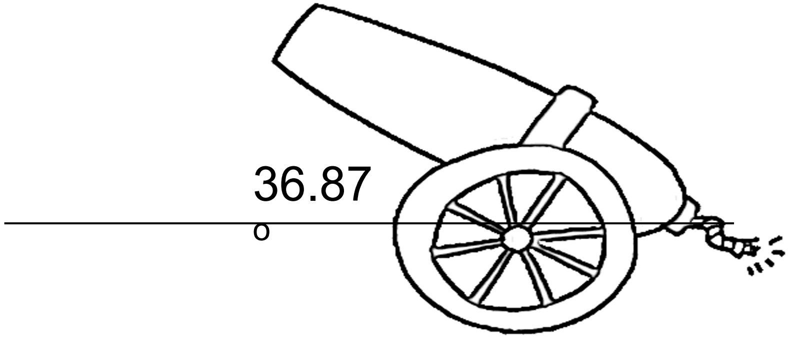
A) Both p_x and p_y of HT and the cannon is conserved in the process of firing the cannon.

B) Only p_y is conserved.

C) Only p_x is conserved.

D) NOTA





A 3400 kg cannon is mounted so that it can recoil freely horizontally. Calculate the magnitude of the recoil velocity when Hunter Thompson (50 kg), undrar mannen, is shot out of the cannon at 500 m/s at $\theta=36.87^{o}$.

www.espn.com/espn/news/story?id=2139349

"The Edge... there is no honest way to explain it because the only people who really know where it is are the ones who have gone over." (H Thompson)

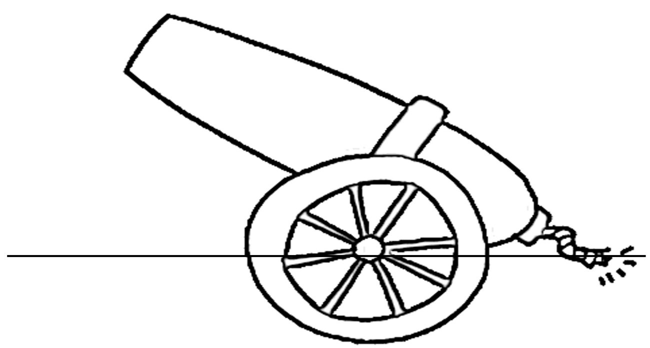
A) 5.88 m/s

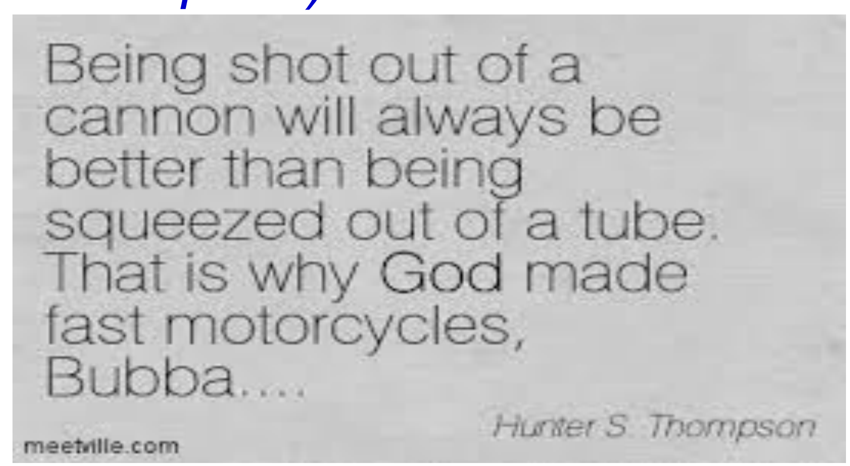
B) 6.34 m/s

C) 7.35 m/s

D) 3.93 m/s

E) NOTA





A 3400 kg cannon is mounted so that it can recoil freely horizontally. Calculate the force of the ground on the cannon, if the explosion takes 10 millisecond.

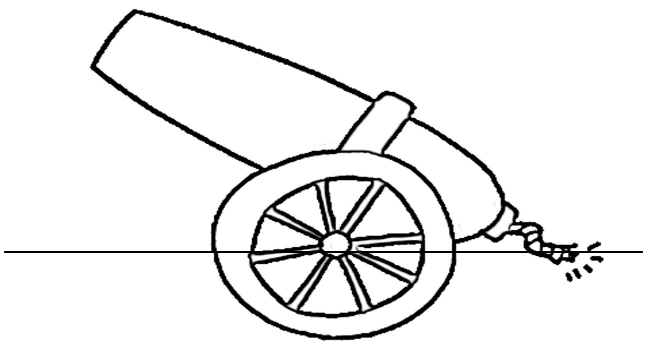
A) 1533810 N

B) 1500000 N

C) 15000 N

D) 33810 N

E) NOTA



A rocket engine burns fuel so fast, up into the night sky it blasts.

If $m_{rocket+fuel}$ =10000 kg and 1000 kg of fuel is expelled at 10^4 m/s every 20 seconds, the velocity and displacement at t=20 seconds is (take the average mass of the 'recoil' as the mass at t=10 seconds, and, for simplicity, ignore the effect of gravity)

https://www.youtube.com/watch?v=XsmCj1YNWH4

A) 3033 m/s, 34 km
B) 124 m/s, 1240 m
C) 423 m/s, 5670 m
D) 1052 m/s, 10520 m
E) NOTA

A 1000 kg rocket, with v_i=0, ejects two 200 kg segments at v=100 m/s, in succession. What is the final velocity of the non-ejected piece?

A) 58.33 m/s
B) 50.79 m/s
C) 25 m/s
D) 100 m/s
E) NOTA

Joseph Kittinger (m=60 kg), nearing the end of his 13 minute descent from h=30 km, decides to 'brake' by throwing a 20 kg bowling ball downwards. At t=20 s, neglecting air resistance, what is v_{BB} such that, after throwing it, he momentarily comes to rest?

A) 10.66 m/s

B) 2467 m/s

C) 892 m/s

D) 784 m/s

E) NOTA

Joseph Kittinger takes 13 minutes to free fall from h=30 km; after 20 seconds, he throws a 20 kg ball downwards. Considering the entire 13 minute period, for which "system" is F_{ext} zero, neglecting air resistance?

A) JK
B) BB
C) JK+BB
D) JK+BB+Earth
E) NOTA

A 4 kg mass, moving with $v_{x,i}$=-2 m/s, collides elastically with a 1 kg mass, with $v_{x,i}$=-4 m/s. What are the final velocities of the two masses after the collision? (check using conservation of KE/momentum)

A) $v_{1,f}$=-4 m/s, $v_{2,f}$=-2 m/s
B) $v_{1,f}$=-4 m/s, $v_{2,f}$=2 m/s
C) $v_{1,f}$=-2 m/s, $v_{2,f}$=-4 m/s
D) $v_{1,f}$=-2.8 m/s, $v_{2,f}$=-0.8 m/s
E) NOTA

A 2 kg mass, moving with $v_{x,i}$=-2 m/s, collides elastically with a 1 kg mass, with $v_{x,i}$=+3 m/s. What are the final velocities of the two masses after the collision? (check using conservation of KE/momentum)

A) $v_{1,f}$= 4/3 m/s, v_{2f}=-11/3 m/s
B) $v_{1,f}$= -4/3 m/s, v_{2f}=-11/3 m/s
C) $v_{1,f}$= -4/3 m/s, v_{2f}=+11/3 m/s
D) $v_{1,f}$= 4/3 m/s, v_{2f}=11/3 m/s
E) NOTA

Ch. 9: Statics and Equilibrium

Two conditions for an object to be stationary: 1) net **F**orce on object=0, i.e., m**a**=0 (this includes $\mathbf{a}_{radial}$); 2) object also in "rotational" equilibrium: net Torque on an object=0

Torque=|**r**||**F**|sin$\theta_{\mathbf{r,F}}$ (+/-); **<u>note that</u>** **<u>|F|sin$\theta_{\mathbf{r,F}}$=F perpendicular to r!</u>**

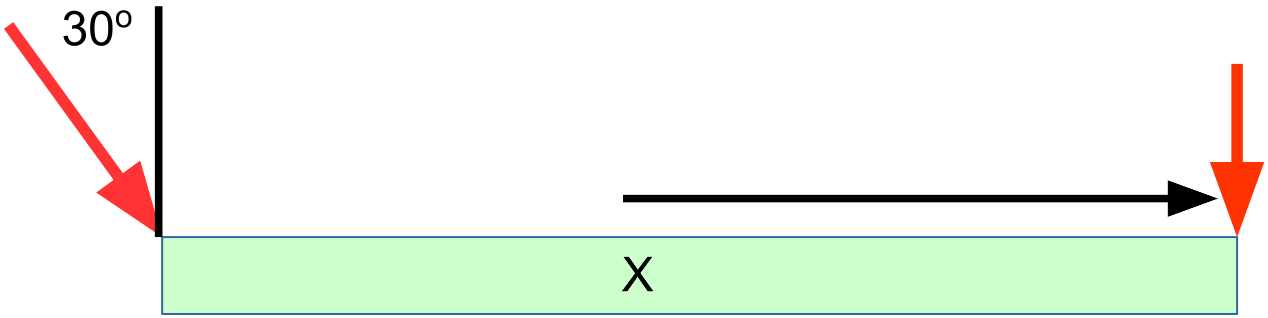
same conventions as before: counterclockwise/clockwise rotations positive/negative. Note the importance of the "axis of rotation", wrt **r** is measured

F_{left}=16N and F_{right}=10N (60 cm from the axis at pt. X) act on Max Plank, meter stick extraordinaire. Neglecting his mass, which is true?

A) He rotates clockwise about X.

B) He rotates counter-clockwise about X.

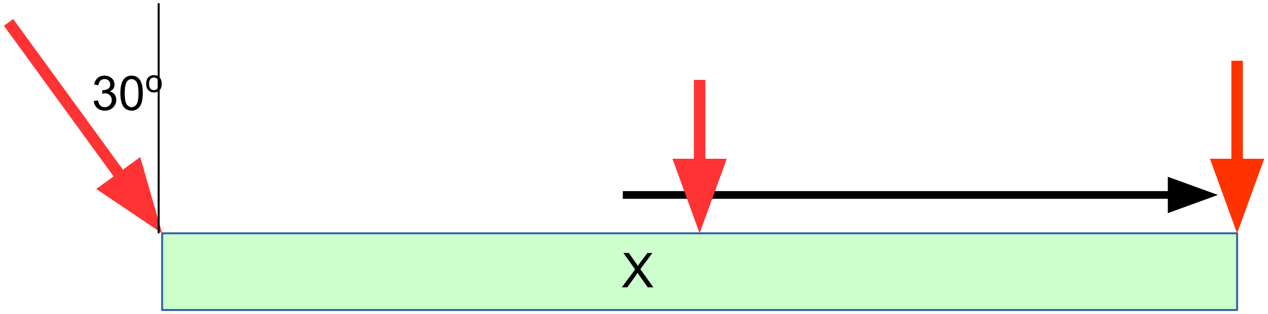
C) He remains stationary.



If we now take into account his 1 kg mass, what is the net torque magnitude?

Note: $F\sin\theta_{r,F} = F$ *perpendicular to r*

A) 0.54 N-m B) 1.44 N-m C) 0.44 N-m D) NOTA



The 2 kg Laika, 不知的狗, is placed 20 cm from the end of the 1 m long, 10 kg Max Plank with 2 supports as shown. What are the values of the support forces N_1 (30 cm from the end shown) and N_2?

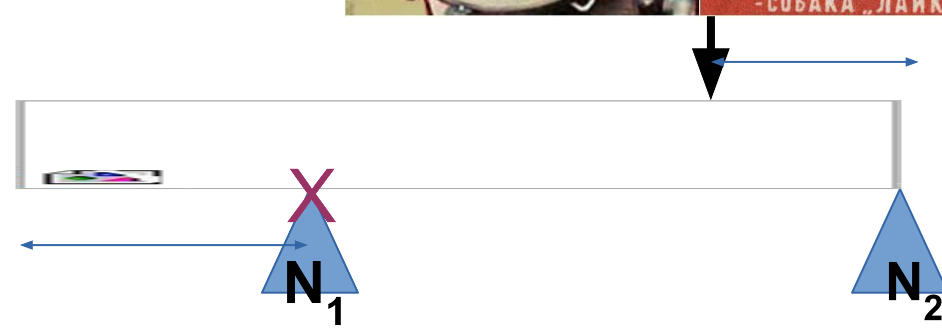
A) N_1=50 N; N_2=50 N

B) N_1=42.2 N; N_2=75.6 N;

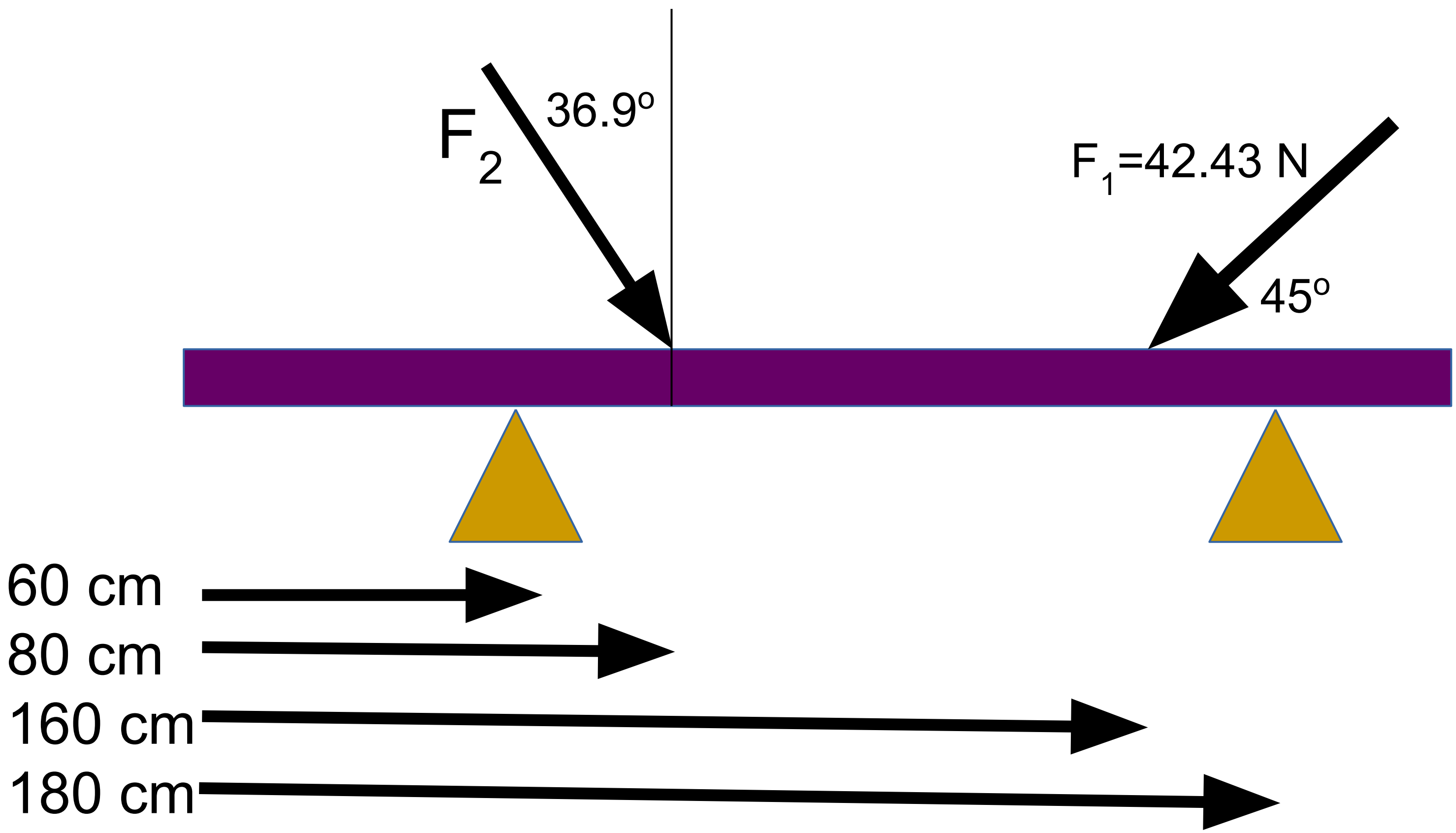
C) N_1=75.6 N; N_2=42.2 N;

D) N_1=75.6 N; N_2=75.6 N;

E) E) NOTA



A 2 kg, 2m long plank is supported by normal forces N_1 (right) and N_2 (left); F_1=42.43 N and F_2 act at the points shown. What is F_2 if the plank is in equilibrium?



A) 48.48 N

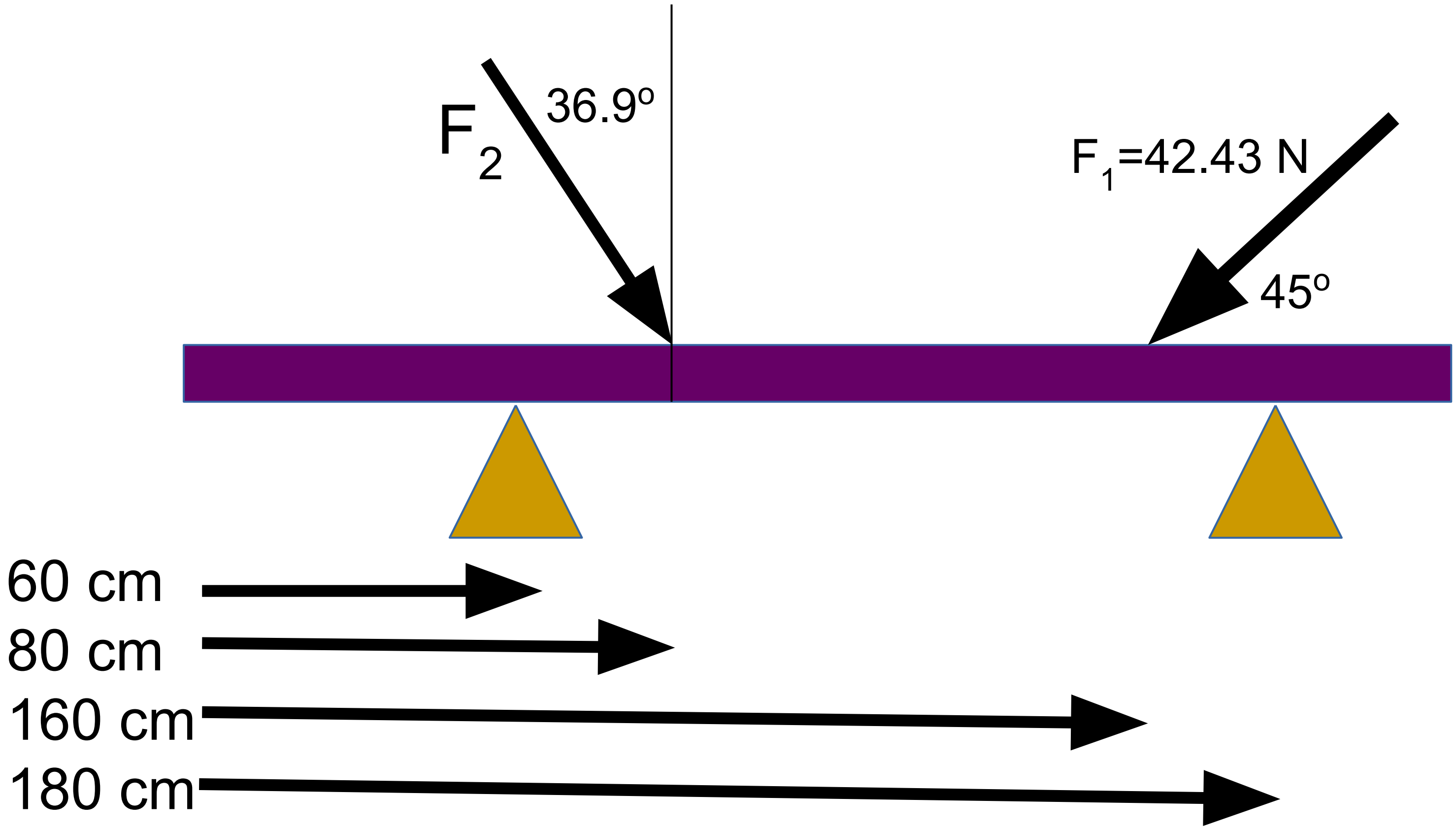
B) 38.2 N

C) 50 N

D) 51.4 N

E) NOTA

What is the value of N_1? (m_{plank}=2 kg)



A) 48.48 N

B) 38.2 N

C) 50 N

D) 51.4 N

E) NOTA

Using torques, what is the value of N_2? (check your answer using $\Sigma F_y=0$)

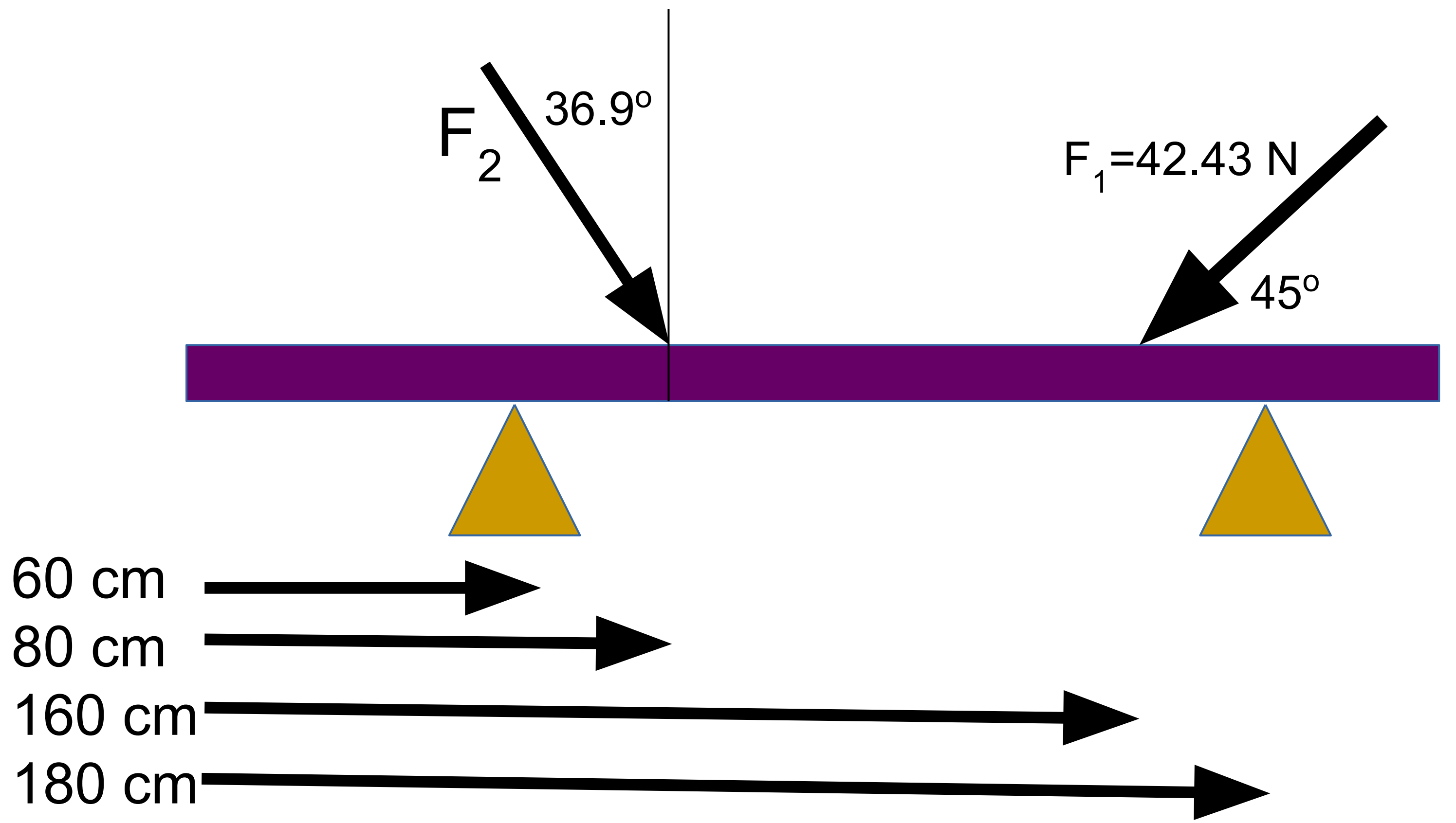
A) 48.48 N

B) 38.2 N

C) 50 N

D) 51.4 N

E) NOTA



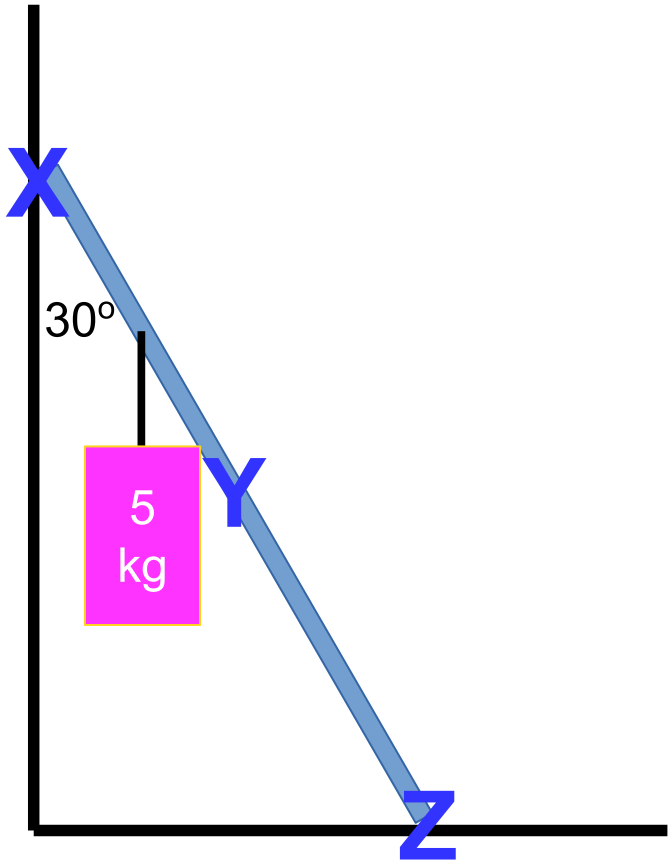
A ladder (2 m long, 10 kg) leans against Roselinksi's wall; a 5 kg weight hangs 50 cm from the top.If the wall were frictionless, and the plank was in equilibrium, to solve for $N_{\text{wall on plank}}$, the best choice for the axis of rotation would be:

A) The point X

B) The point Y (center-of-mass of plank)

C) The point Z

D) NOTA



A ladder (2 m long, 10 kg) leans against Roselinksi's wall; a 5 kg weight hangs 50 cm from the top. If the wall were frictionless, and the plank was in equilibrium, the normal force of the wall on the plank would have magnitude:

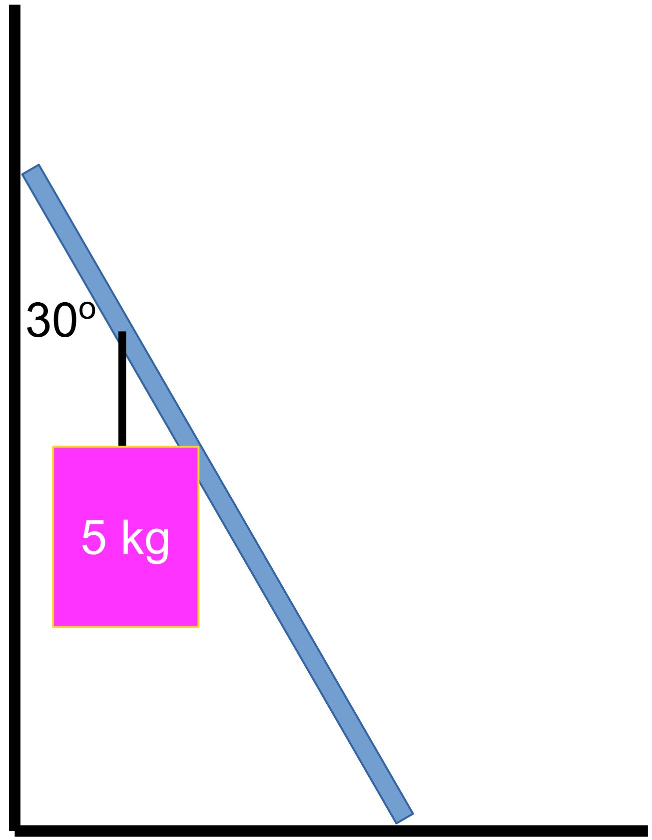
A) 49.5 N

B) 147 N

C) 77.8 N

D) 99 N

E) NOTA



A ladder (2 m long, 10 kg) leans against Roselinksi's (frictionless) wall; a 5 kg weight hangs 50 cm from the top. If the plank was in equilibrium, and if θ is increased at all, the plank slips, then the coefficient of static friction of the floor on the plank is:

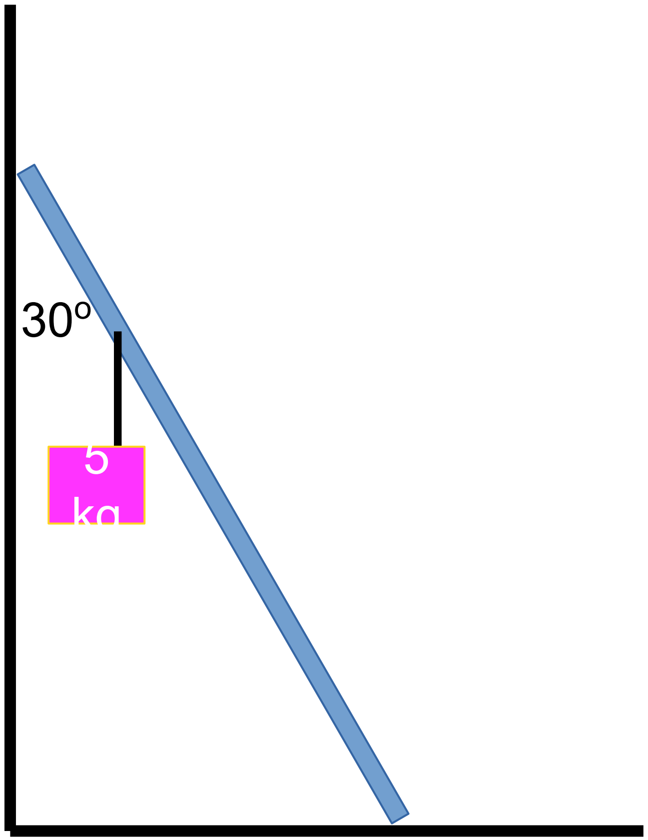
A) 0.21

B) 0.252

C) 0.317

D) 0.336

E) NOTA



If both the wall and the floor have friction, the total number of forces acting on the plank in x- and y-, respectively, are:

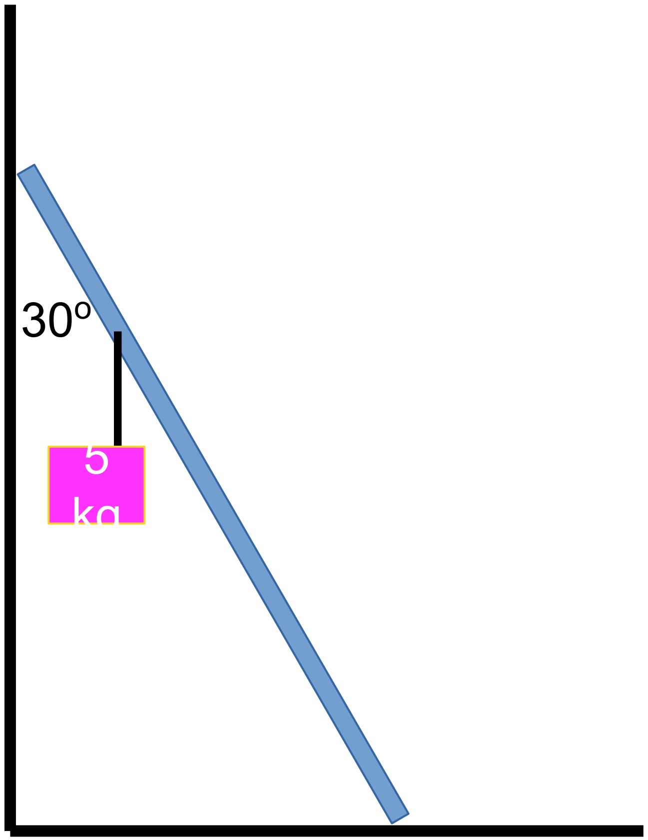
A) 2, 3

B) 2, 4

C) 3, 2

D) 3, 3

E) NOTA



Taking the point X as the axis of rotation, then, if both the wall and the floor are rough, the total number of (+) and (-) torques are:

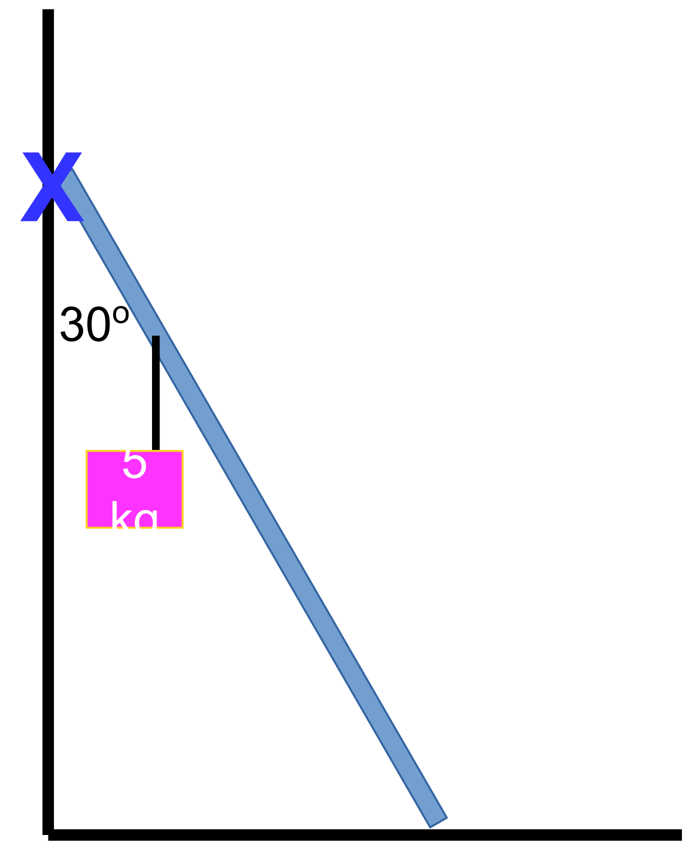
A) 2,4

B) 1,3

C) 2,3

D) 2,2

E) NOTA



Write all the equations you would use to solve for the normal forces and the frictional force on the floor, in the case where the wall is frictionless.

Relative to the center-of-mass of the plank, the number of (+) and (-) torques are (assume wall has friction):

A) 1,4
B) 3,2
C) 2,3
D) 4,1
E) NOTA

A horizontal force F_{ext} is applied to a plank, in equilibrium. Which is true?

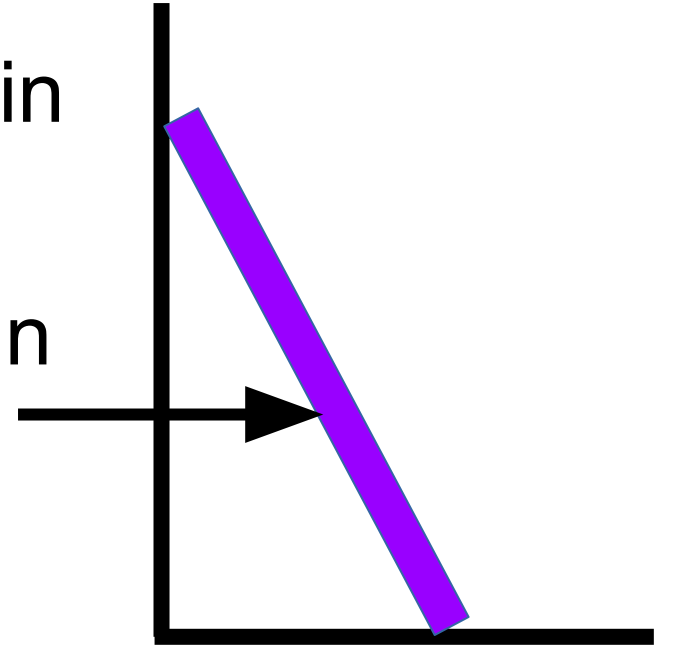
A) $F_{friction,\ floor\ on\ plank}$ must point along -x

B) $F_{friction,\ floor\ on\ plank}$ must point along +x

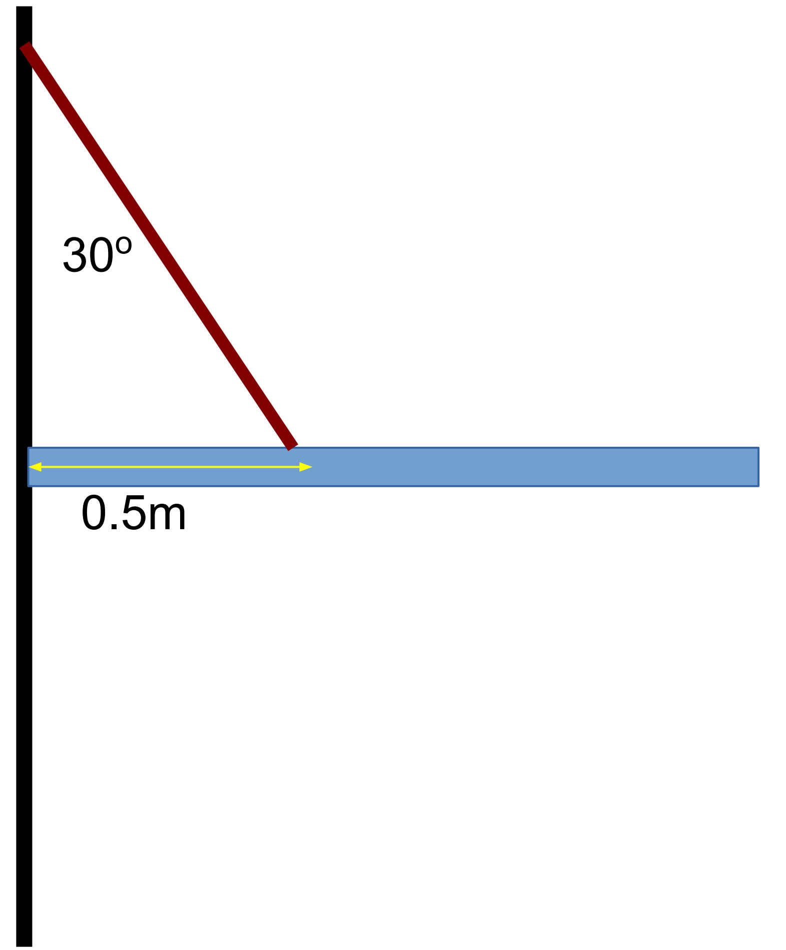
C) $N_{wall\ on\ plank}$ must be smaller than in the case without F_{ext}

D) $N_{floor\ on\ plank}$ must be larger than in the case without F_{ext}

E) Two (or more) of the above are true.



What is coefficient of static friction μ_s between the board (m=10 kg, l=1.2 m) and wall, assuming the board is at limit of equilibrium?



A) 1.1

B) 0.43

C) 0.29

D) 0.17

E) NOTA

A 2 m planck, having mass 10.2 kg leans against a wall; it is suspended at a 30° angle by a rope with tension T, 80 cm from its far end. Assuming the planck is in equilibrium, the Tension in the rope is:

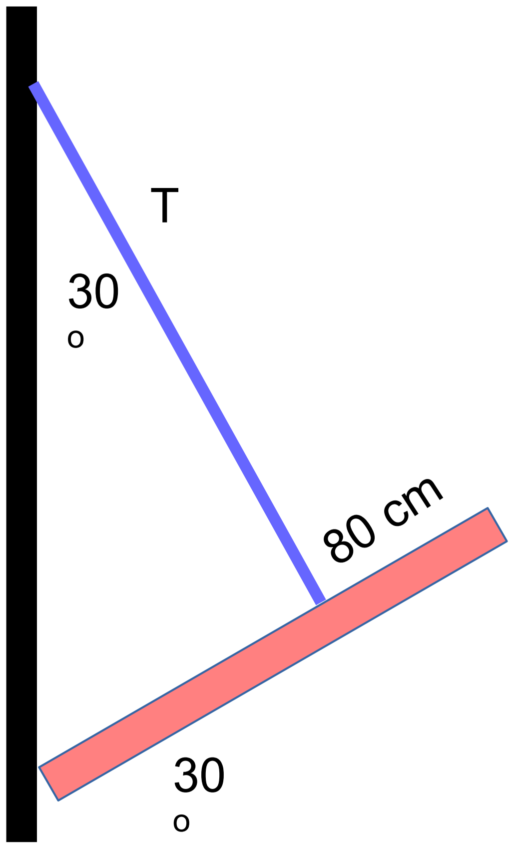
A) 72.16 N

B) 36.1 N

C) 62.5 N

D) 50 N

E) NOTA



A 2 m planck, having mass 10.2 kg leans against a wall; it is suspended at a 30° angle by a rope with tension T, 80 cm from its far end. Assuming the planck is in equilibrium, the force of static friction of the wall on the plank is:

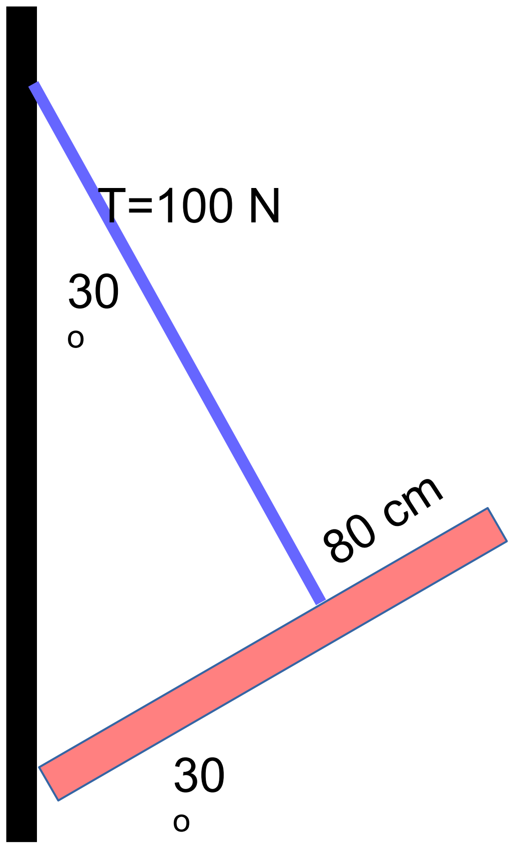
A) 72.16 N

B) 36.1 N

C) 62.5 N

D) 50 N

E) NOTA



In the same problem, assuming the 10.2 kg planck is in linear equilibrium, the normal force of the wall on the plank is:

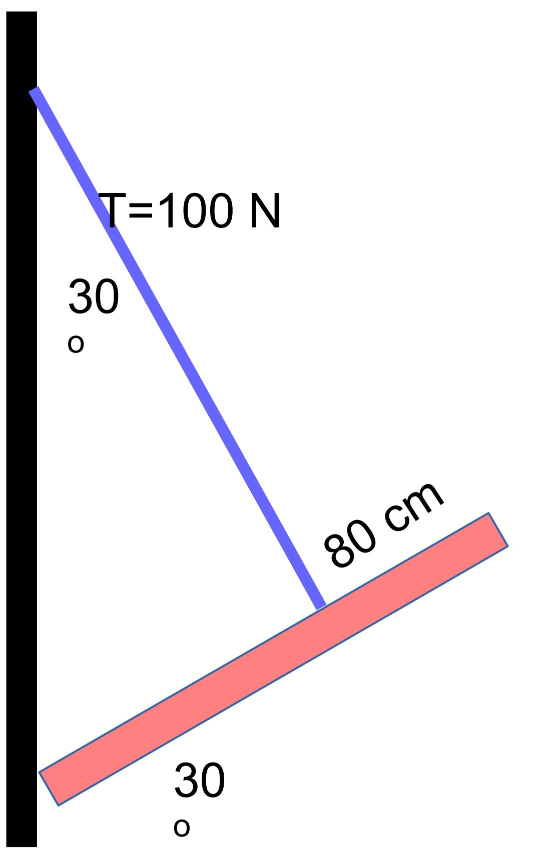
A) 72.16 N

B) 36.1 N

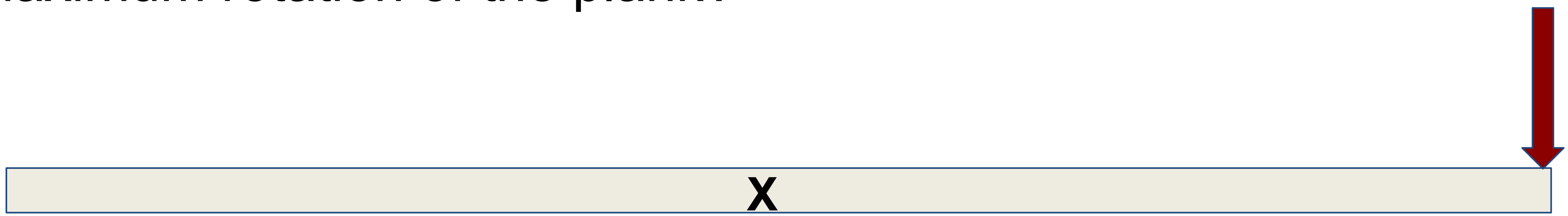
C) 62.5 N

D) 50 N

E) NOTA

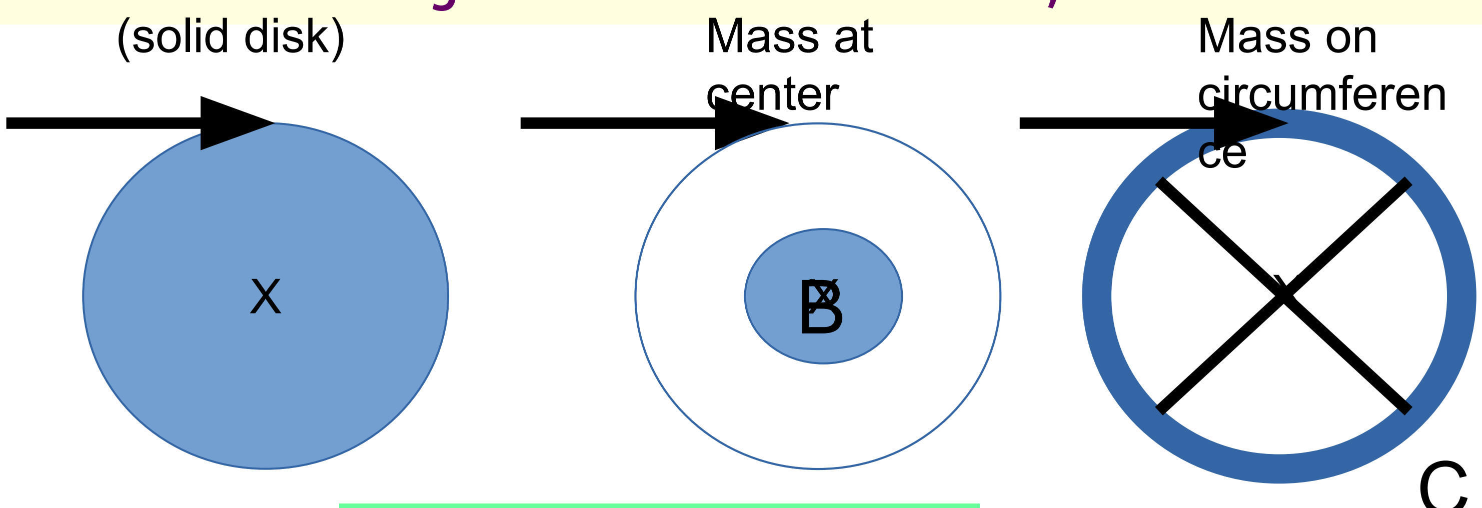


A 10-kg, 1 meter plank, constrained at its center, has a single force acting on it. Which mass distribution would give the maximum rotation of the plank?



1. Mass uniformly distributed along the length of the plank
2. All mass concentrated at the center of the plank
3. Mass concentrated at the ends of the plank.
4. All of the above would give the same rotation

After years of previously-futile work in his cave, and equally long years of being ostracized from the tribe of Sasnak, Grog* announces that he has perfected a new invention, which he calls the “I-wheel”, consisting of a round piece of wood fixed at one point (X), and set into rotation by pushing along the edge, which, he announces, he will demonstrate at half-time of the upcoming Saturday Club-Thy-Neighbor Festival. ***For a given amount of applied Grog push, which type of I-wheel shown will result in the greatest rotation, assuming they all have the same mass*** (and thereby giving Grog the greatest chance of winning the heart of the wise, noble and virtuous Princess Nire?)



D) All rotate at the same rate

A

Related: Tour-de France bikes minimize mass on rim or axle?

Follow Grog's newest inventions on Facebook!

Imagine dividing each of Grog's I-wheels into 4 pieces, each with mass M/4 and at a distance r from the axis of rotation. For each piece, you calculate $I_i=(M/4)r^2$, where r is the distance of that piece relative to the axis. You then add up all the four values of I_i to give you the total "moment-of-inertia" for the "total" I-wheel. From such an approach, what would you conclude about the relative moments of inertia of the three I-wheels?

A) $I_A>I_B>I_C$

B) $I_A<I_B<I_C$

C) $I_A=I_B=I_C$

D) $I_B<I_A<I_C$

E) NOTA

A 10N force is applied at point P 1 m from the center, at a 36.87° angle, to a 2 meter radius, 500 g. solid disk. Determine the total angular displacement after 2 seconds, assuming it has an initial clockwise angular velocity of 4 rads/s.

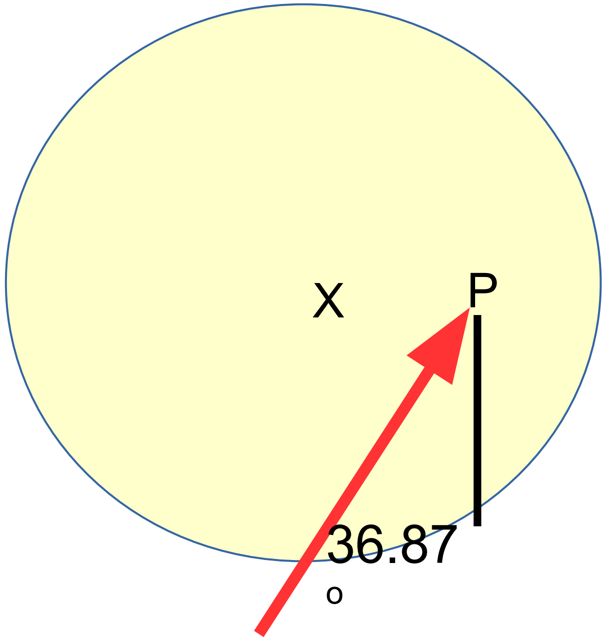
A) 8 rads

B) 16 rads

C) -8 rads

D) -4 rads

E) NOTA



A 10N force is applied at point P 1 m from the center, at a 36.87° angle, to a 2 meter radius, 500 g. solid disk. Determine the work done by the 10N force after 2 seconds, if the disk has an initial clockwise angular velocity of 4 rads/s.

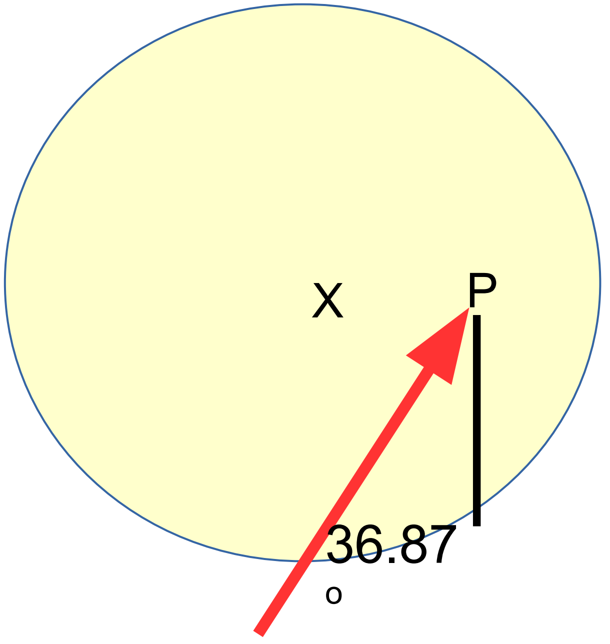
A) 64 J

B) 132 J

C) 128 J

D) 144 J

E) NOTA



Suppose the applied force was applied in the exact same direction, with the same orientation, but at the points Y (vertically displaced) and Z (horizontally displaced). What would be the relative rankings of the magnitude of the angular acceleration?

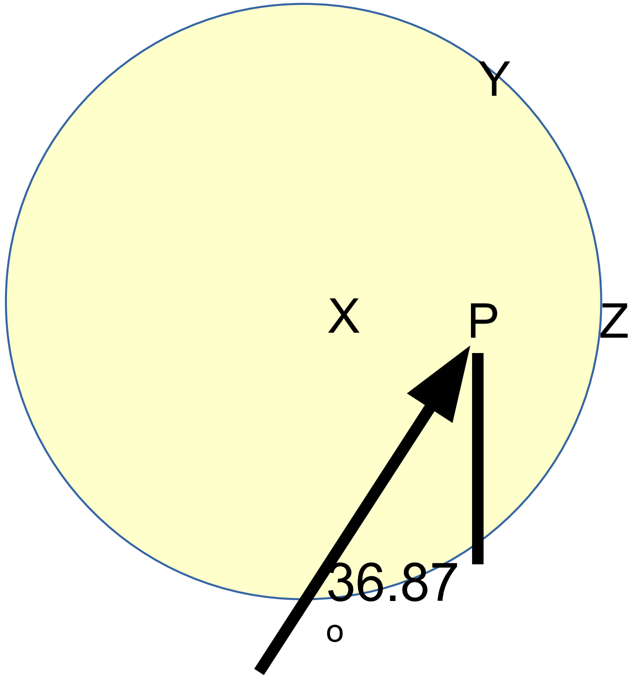
A) $\alpha_P > \alpha_Y > \alpha_Z$

B) $\alpha_P < \alpha_Y < \alpha_Z$

C) $\alpha_P = \alpha_Y = \alpha_Z$

D) $\alpha_Y < \alpha_P < \alpha_Z$

E) NOTA

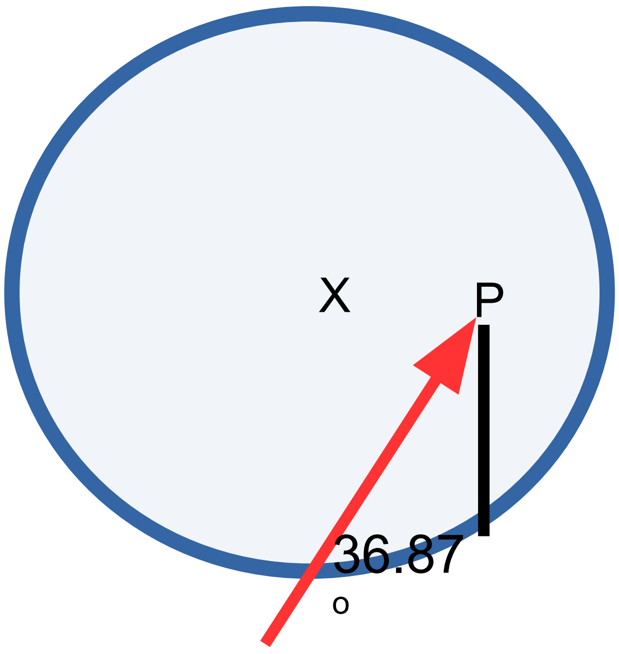


In the $\tau = I\alpha$ problem, suppose the mass were concentrated on the rim. In that case, the angular acceleration α would

A) increase

B) decrease

C) Be unchanged



Grog, redux...

A hoop of mass 2 kg and r=1 m falls on top of a solid, 2 kg mass disk of radius 2 m with an initial counter-clockwise rotation of magnitude $|\omega_i|$=4 rad/s. How much heat is generated in the "collision"?

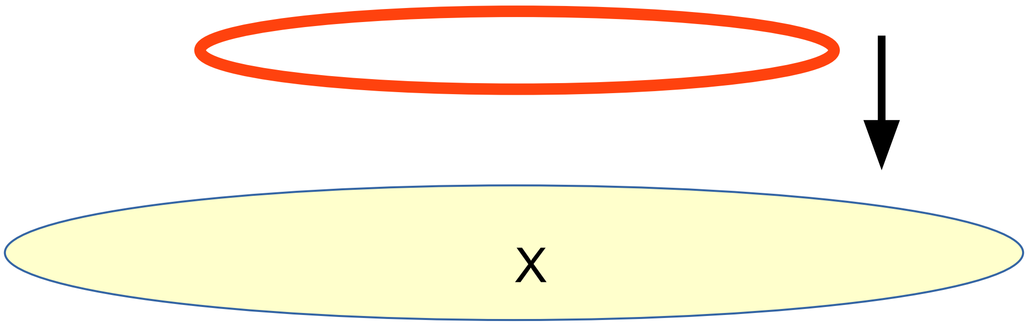
A) 13.86 J

B) 12.44 J

C) 5.33 J

D) 10.66 J

E) NOTA



A 2 kg rod of total length 3 meters, rotating clockwise about its end with $|\omega_{rod}|$=4 rads/s, falls on top of a solid 4 kg disk of radius 2 m, rotating c.c. about its center with $|\omega_{rod}|$=6 rads/s. Find ω_f of the composite object and the heat generated in the 'collison'

$I_{rod, end}=ML^2/3$; $I_{disk, center}=MR^2/2$. Here $I_{rod}=2*3*3/3=6$ kg-m^2; $I_{disk}=4*2*2/2=8$ kg-m^2; $L_{rod}=-24$; $L_{disk}=+48$, so $+24=(6+8)\omega_f$, so $\omega_f=(24/14)$ rad/s.

Now calculate heat: $KE_{initial}=KE_{final}$+heat generated, so heat= $KE_{initial}-KE_{final}=0.5*6*(-4)*(-4)+0.5*8*6*6-0.5*14*(24./14)*(24./14)=171.43$ J

In the previous problem, if the top disk was solid and the bottom disk were a hoop, the heat generated would be, relative to the previous case

A) Increased

B) Decreased

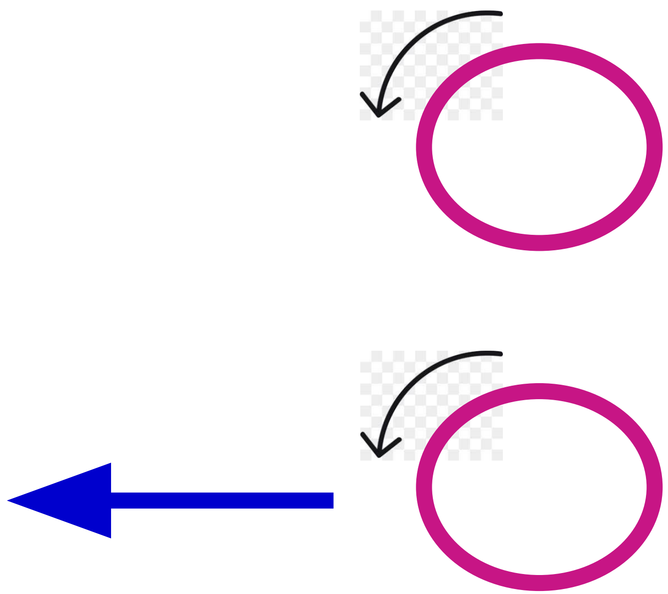
C) Unchanged

Comparing the magnitude of work required to bring to rest: a) a hoop rotating at 2 rad/s, or b) the same hoop rotating at 2 rad/s and moving at 2 m/s (i.e. rolling), you would expect:

A) $W_a=W_b$

B) $W_a<W_b$

C) $W_a>W_b$



Laika is spinning on his skates at Crown Center. To demonstrate his skating acumen, he suddenly lifts the two 10 kg masses which he is A) initially holding directly underneath him so that they are B) directly in front of him and then C) directly out to his sides. Rank his rotational speeds in the three cases.

A) $\omega_A > \omega_B = \omega_C$

B) $\omega_A > \omega_C > \omega_B$

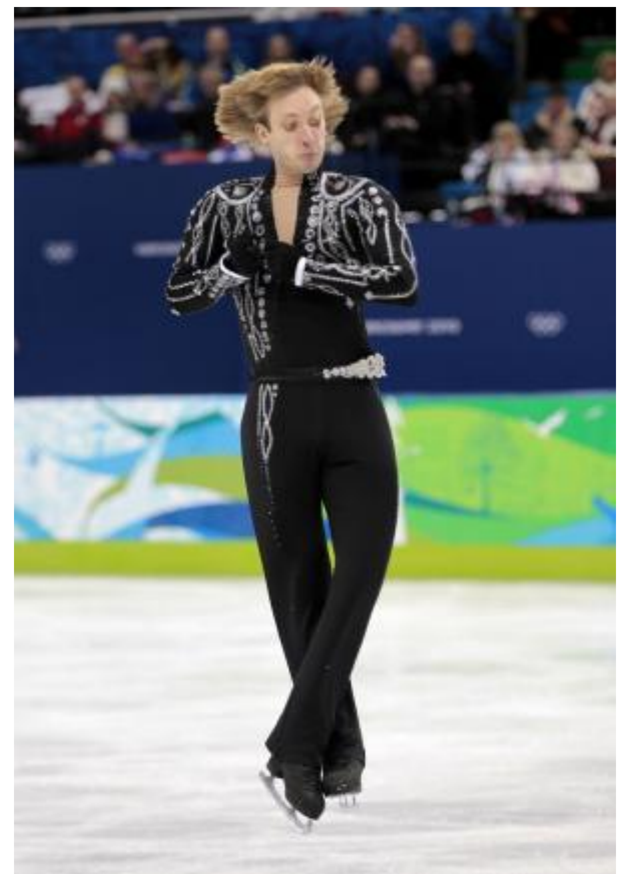
C) $\omega_C > \omega_B > \omega_A$

D) $\omega_C > \omega_A > \omega_B$

E) NOTA

Ivan Shmuratko, modeled as a solid center cylinder of mass **60 kg** and radius **10 cm**, holds two identical **4 kg** masses at an initial distance **1 m** from his center, and is spinning with an initial angular velocity **10 rads/s, clockwise.** He now pulls the two masses to a new radius **12 cm**. His final angular rotational velocity is:

A) 200 rad/s, clockwise
B) 83 rad/s, clockwise
C) 83 rad/s, c.c.
D) 166 rad/s, clockwise
E) NOTA



деньги мегагранта

Two 3 kg masses are connected by a massless rod having total length 6 m, and initially rotating c.c. about their center with ω_i=4 rad/s. They fall on a rough surface, and come to rest in 2 s. The total angular displacement of each mass is:

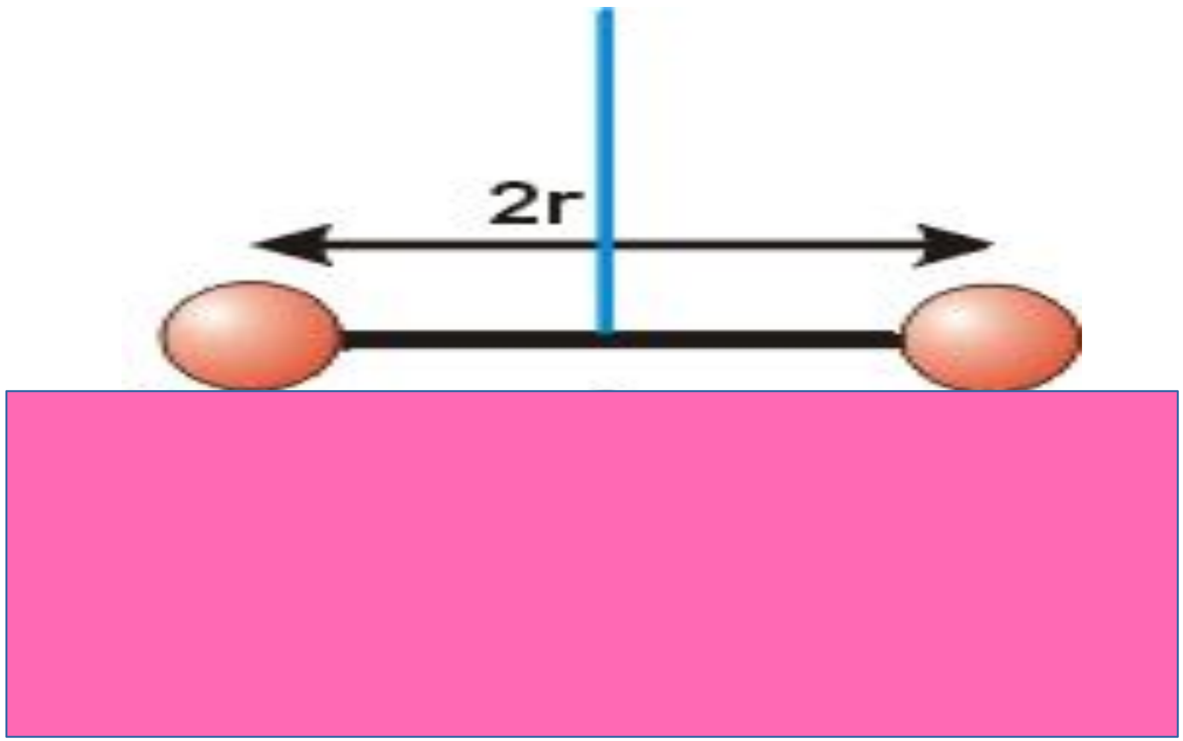
A) 0 rad

B) 4 rad

C) 8 rad

D) 16 rad

E) NOTA



Two 3 kg masses are connected by a massless rod having total length 6 m, and initially rotating about their center with ω_i=4 rad/s. They fall on a rough surface, and come to rest in 2 s. The total work done by friction on the 2 masses is:

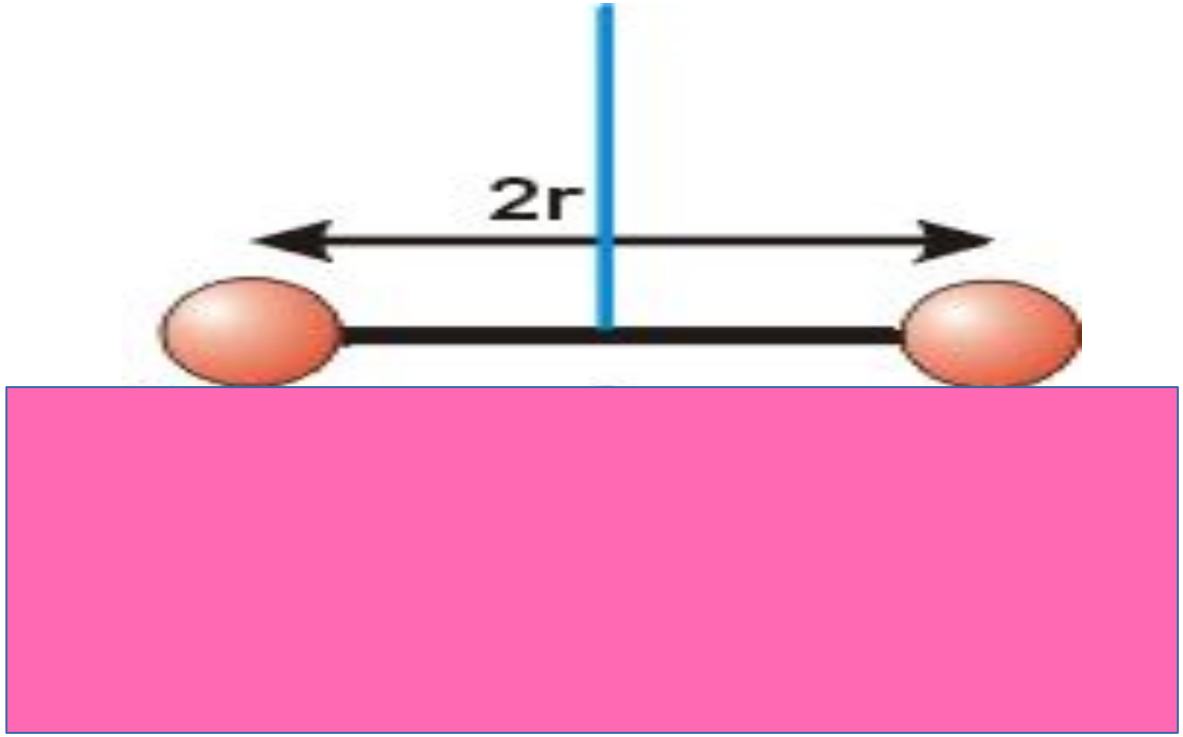
A) 432 J

B) 27 J

C) -27 J

D) -432 J

E) NOTA



Two 3 kg masses are connected by a massless rod having total length 6 m, and initially rotating about their center with ω_i=4 rad/s. They fall on a rough surface, and come to rest in 2 s. The coefficient of kinetic friction is:

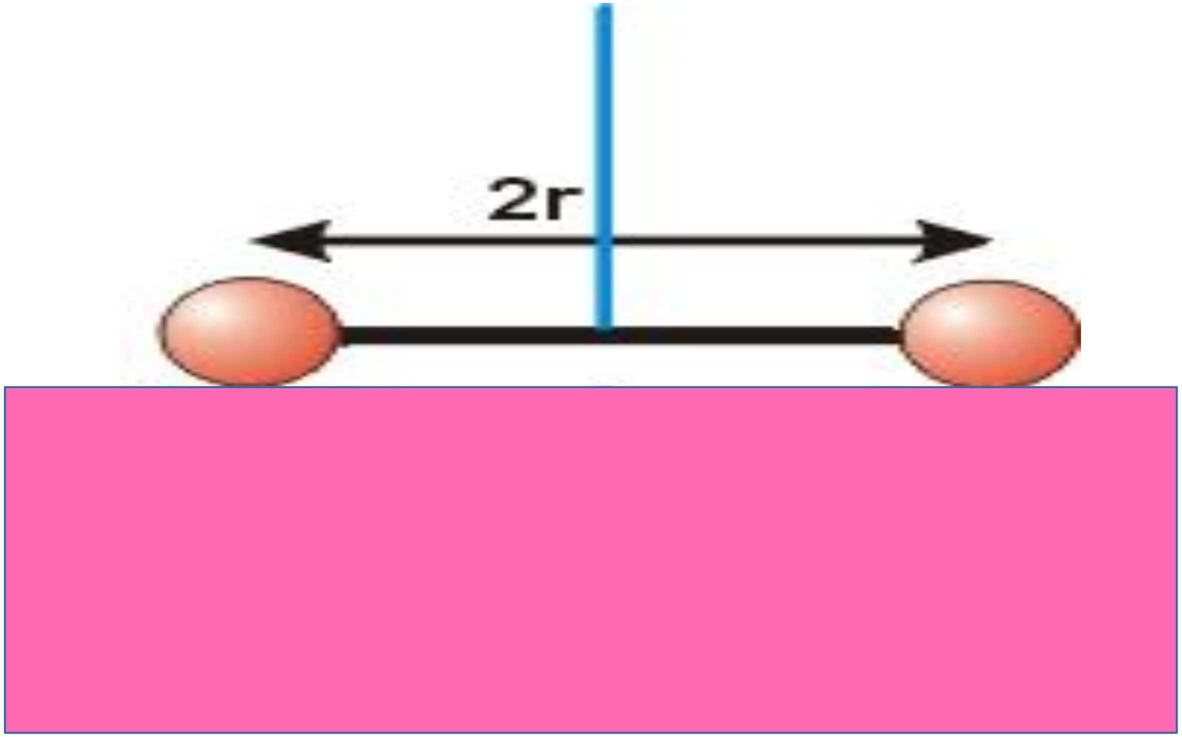
A) 0.31

B) 0.61

C) 0.38

D) 0.16

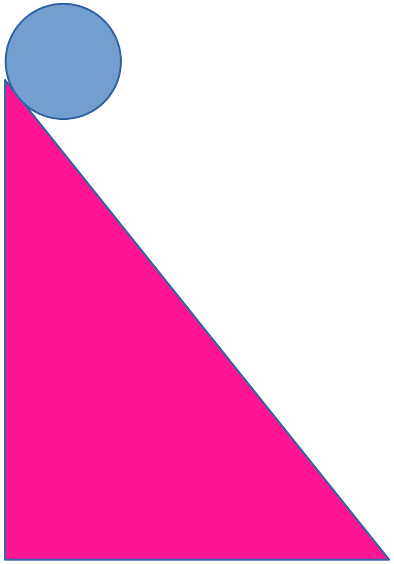
E) NOTA



A 4 kg hoop of diameter 10 m, rotating clockwise about its end with $|\omega_{rod}|$=8 rads/s, falls on top of a table, coming to rest after 8 seconds. Determine the coefficient of kinetic friction, between the hoop and the table.

$I_{hoop}=MR^2=4*5*5=100$. First, find total angular displacement θ, $\theta_f=\theta_i+\omega t+0.5\alpha t^2$ requires angular acceleration α: $\omega_f=\omega_i+\alpha t$; 0=-8 rads/s+αt=>α=1 rad/s^2; so θ_f=-8*8+0.5*1*64, so θ_f=-32 rads. Now set change in rot KE equal to τΔθ; $\Delta KE=0.5*I*(\omega_i^2-\omega_f^2)$=-0.5*100*64=-3200 J=-4*9.8*5*32*μ_K, so μ_K=3200./(4*9.8*5*32)=0.051.

A 2m radius hoop of mass 2 kg, and a 2 m radius disk of mass 2 kg are placed at the top of a 66.42° incline 40 m along the ground. When they both reach the bottom of the incline, what is the total work done by (gravity) on the hoop vs. the disk (recall the relationship b/w W_{grav} and ΔKE)?



A) $|W_{g,disk}| = |W_{g,hoop}|$

B) $|W_{g,disk}| < |W_{g,hoop}|$

C) $|W_{g,disk}| > |W_{g,hoop}|$

In same problem, which object reaches bottom faster?

A) hoop

B) disk

C) reach ground at same time

An icecube, a 2m radius hoop of mass 2 kg, and a 2 m radius disk of mass 2 kg are placed at the top of a 66.42° incline 40 m along the ground. Assuming the icecube slides without friction, which is true regarding the relative time it takes the 3 objects to reach the bottom of the incline?

A) $t_{cube}<t_{disk}<t_{hoop}$

B) $t_{cube}=t_{disk}=t_{hoop}$

C) $t_{cube}>t_{disk}>t_{hoop}$

D) $t_{disk}<t_{cube}<t_{hoop}$

E) NOTA

A 2m radius hoop of mass 2 kg, and a 2 m radius disk of mass 2 kg are placed at the top of a 66.42^o incline 40 m along the ground. When they both reach the bottom of the incline, what is true regarding the relative linear KE of the two objects and also the relative rotational KE of the two objects?

A) $KE_{linear, hoop} > KE_{linear, disk}$; $KE_{rot, hoop} > KE_{rot, disk}$

B) $KE_{linear, hoop} < KE_{linear, disk}$; $KE_{rot, hoop} < KE_{rot, disk}$

C) $KE_{linear, hoop} < KE_{linear, disk}$; $KE_{rot, hoop} > KE_{rot, disk}$

D) $KE_{linear, hoop} > KE_{linear, disk}$; $KE_{rot, hoop} < KE_{rot, disk}$

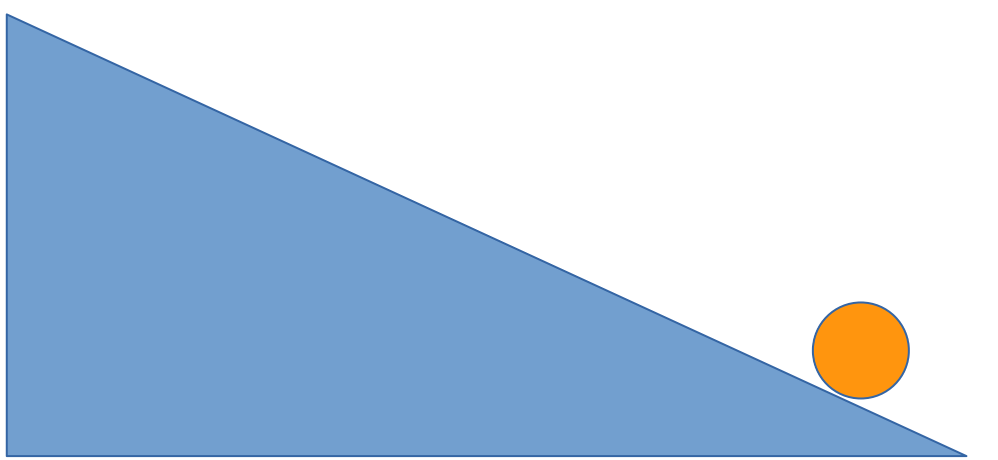
E) NOTA

Laika, diegenur hunschenzheznof wundzerkernon, pulls a 2 kg, 0.5 m radius hoop, initially at rest, up a 36.87° incline 80 m along the base. At the top of the incline, the hoop is rotating at 2 rads/s. How does the magnitude of work done by Laika compare with the gravitational work?

A) $|W_{laika}|<|W_{grav}|$
B) $|W_{laika}|>|W_{grav}|$
C) $|W_{Laika}|=|W_{grav}|$

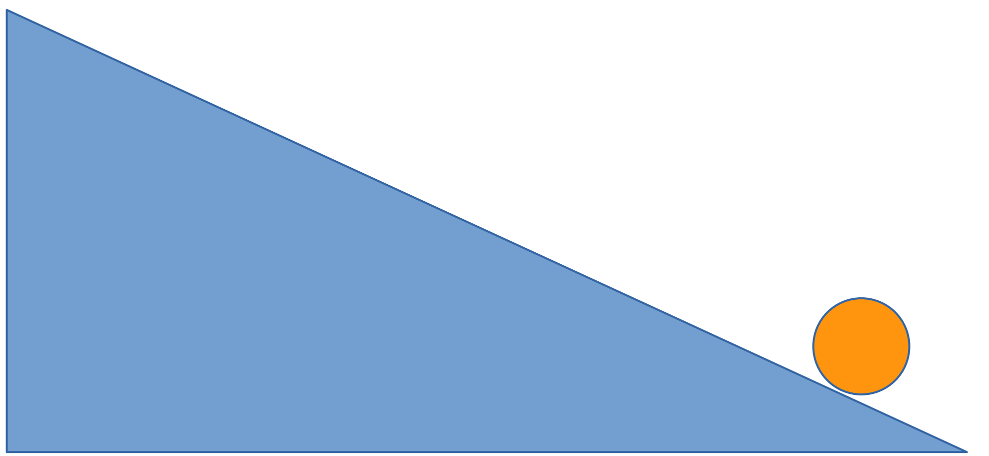
Laika, diegenur hunschenzheznof wundzerkernon, pulls a 2 kg, 0.5 m radius hoop, initially at rest, up a 36.87° incline 80 m along the base. At the top of the incline, the hoop is rotating at 2 rads/s. Determine the total *linear* and *rotational* work done on the hoop

A) 2 J, 2 J
B) 0 J, 2 J
C) 1 J, 2 J
D) 1 J, 1 J
E) NOTA



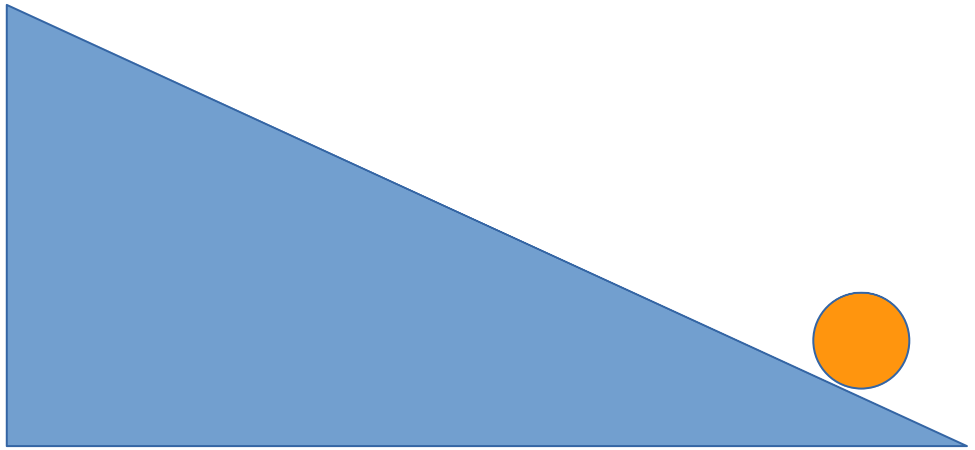
Laika, diegenur hunschenzheznof wundzerkernon, pulls a 2 kg, 0.5 m radius hoop, initially at rest, up a 36.87° incline 80 m along the base. At the top of the incline, the hoop is rotating at 2 rads/s. Determine the work done by all external forces

A) W_{grav}=-1176 J; W_L=1178 J
B) W_{grav}=-2 J; W_L=4 J
C) W_{grav}=1176 J; W_L=-1178 J
D) W_{grav}=-4 J; W_L=2 J
E) NOTA



Laika, diegenur hunschenzheznof wundzerkernon, pulls a 2 kg, 0.5 m radius hoop, initially rotating at 4 rad/s, up a 36.87° incline 80 m along the base. At the top of the incline, the hoop is rotating at 2 rad/s. The signs of W_{tot}, W_{grav} and W_{laika} are:

A) +, +, -
B) -, -, +
C) -, +, +
D) +, -, -
E) NOTA



A solid disk (M=2 kg; R=4 m) has an initial angular velocity ω_i=12 rad/s at the bottom of a 30 degree incline 17.32 m along the base. At the top of the incline, as the result of an external force F, ω_f=4 rad/s. Determine the work done by all the forces acting on the disk.

1. Determine W_{tot}=ΔKE(linear)+ΔKE(rotation): =½ mv^2+½ $I\omega^2$; I=½ MR^2; ω=v/R so W_{tot}=¾ mv^2 for a disk. At bottom of incline, v=12*4=48 m/s; at top of incline, v=4*4=16 m/s, so total work done=0.75*2*(16*16-48*48)=-3072 J, of which ⅓ should be ΔKE(rot)=-1024 J. CHECK using 0.5*I*(16-144); I=0.5*2*16=16, so: 8*128=1024! Checks out!

2. Total work=work done by external force plus work done by gravity; W_{grav}=-2*9.8*10=2*9.8*20*cos(120)=-196 J, so W_{ext}=-2876 J

3. Now disk released from top of incline - in this case, mgh=3/4mv^2 and solve for velocity - note velocity independent of R, M, etc, only depends on height difference

Fluids

(Static: 11.1-11.8; Moving: 12.1-12.5)

1) Under a vertical weight of fluid, the total force exerted is the weight force of the column of fluid. Convenient to define Pressure=F/A

2) Within a static fluid, the net force on a chunk of fluid must be zero in all directions (otherwise the chunk moves)=> for a continuous sample along x, pressure is uniform in all directions (imagine punching a hole in a protrusion under pressure). Pressure under column of height h=ρgh (mg/A)

3) Archimedes' principle: The force on a submerged object is equal to the volume of the displaced fluid.

A 10 cm radius soccer ball is ¾-submerged in champagne ($\rho=0.8\rho_{water}$). If the soccer ball has a mass of 204 g, what is the tension in a string holding the ball to the bottom of the Cup?

A) 32.83 N

B) 24.62 N

C) 61.56 N

D) 22.62 N

E) NOTA

Now the soccer ball is filled with champagne ($\rho=0.8\rho_{water}$) and the cup is filled with hot chocolate ($\rho=2\rho_{water}$). What is the tension in the cable now?

A) 32.83 N

B) 24.62 N

C) 61.56 N

D) 26.73 N

E) NOTA

Laika suspends a cubical rock ($\rho=3\rho_{water}$), 20 cm on a side, by a string, halfway in water. What is the string tension?

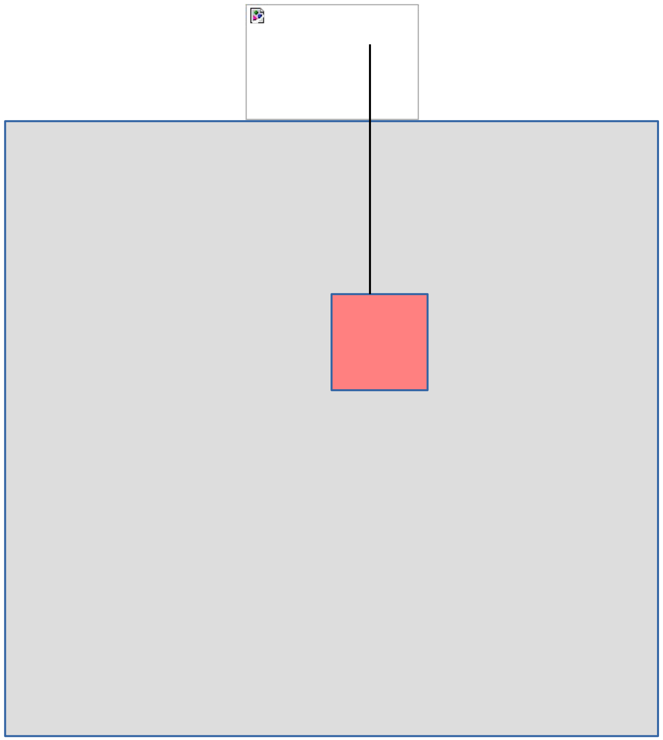
A) 196 N

B) 156.8 N

C) 78.4 N

D) 235.2 N

E) NOTA



In the previous slide, if the rock were deeper in the water, which of the following quantities would increase?

A) The force of the water on the top of the rock
B) The force of the water on the bottom of the rock
C) The tension in the string
D) Two of the above
E) All of the above

A 2 m^3 wooden block ($\rho = 0.5\rho_{water}$) is 75% submerged in water, and is held in place by two ropes, each of which make an angle of 30° wrt vertical. The tension in each rope is:

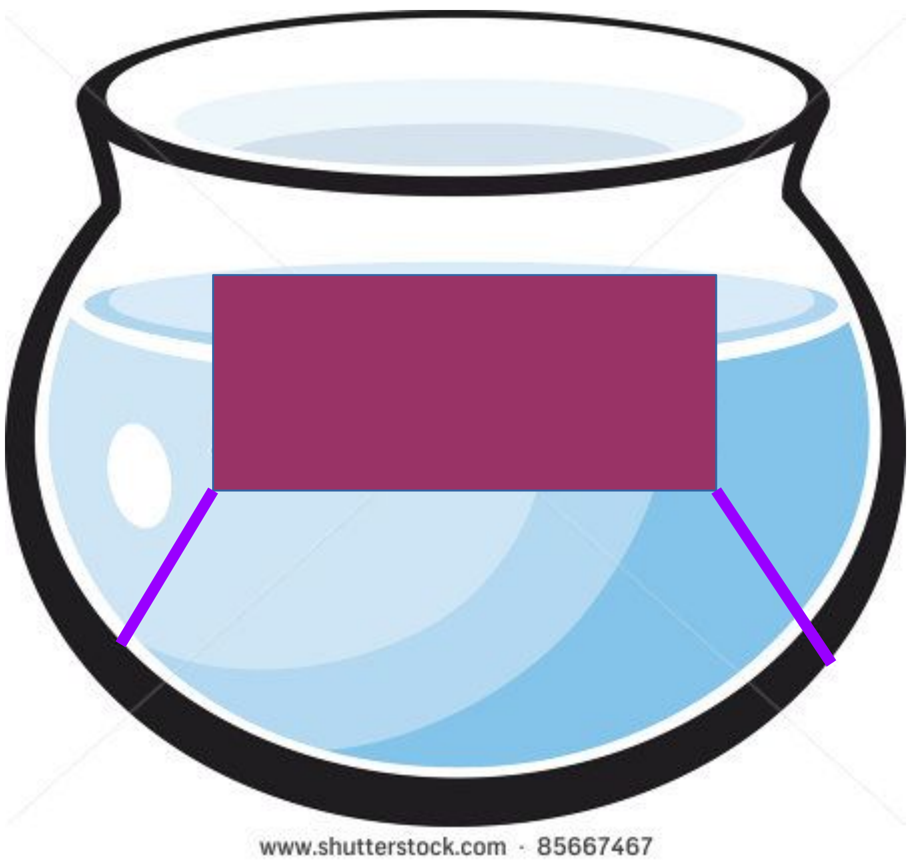
A) 4990 N

B) 2495 N

C) 2829 N

D) 1414 N

E) NOTA



What is the total **downward** force on the water (ρ_{water}=1000 kg/m^3) at the bottom of the left-most pink fluid, given that it has density 0.5ρ_{water} and that the cylindrical column is 10 cm in radius? (P_0=1.01325 x 10^5 Pa)

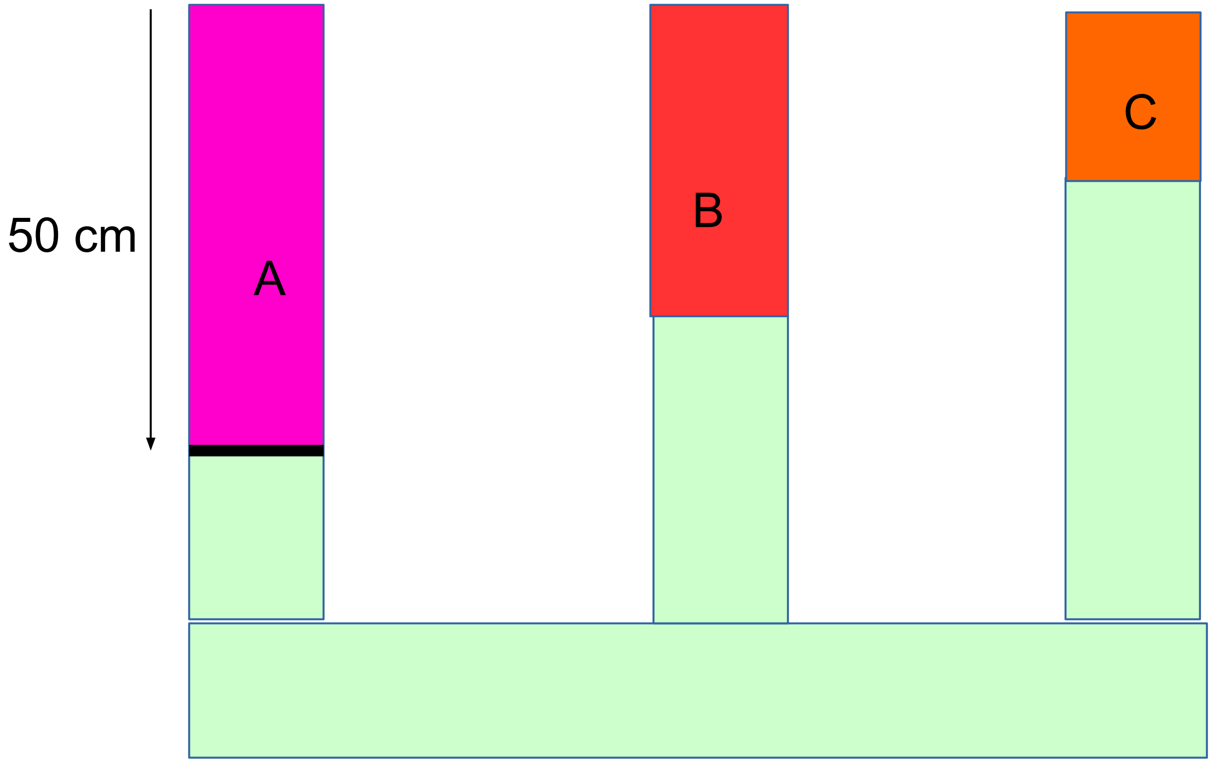
A) 980 N

B) 3260 N

C) 101325 N

D) 103450 N

E) NOTA



Rectangular solid, 2 m x 3 m x 4 m = W x L x H; density=20% water, 50% submerged in water. Tension in a cable attached to bottom=?

ρ_{water}*g*$V_{submerged}$=1000*9.8*12=117600 N = buoyancy force
downwards weight force=200*24*9.8=47040 N, so tension=70560.0 N

pressure at the bottom of the rectangular solid: halfway submerged, so
ρ_{water}*g*2m=1000*9.8*2=19600 Pascals; compare with atmospheric pressure=101325 Pa

Balloon radius 4 meters on Venus, filled with Earth air - g on Venus=8.87/rho=65 kg/m^3, so net force=
(4/3)*pi*4*4*4*65*8.87-(4/3)*pi*4*4*4*1.24*8.87=113710.8 N; divide by mass to get acceleration=113710.8/(4/3)*pi*4*4*4*1.24=456 m/s^2, so, in 10 seconds,
yf=0+0+0.5*456*100=22800 meters, vf=4560 m/s

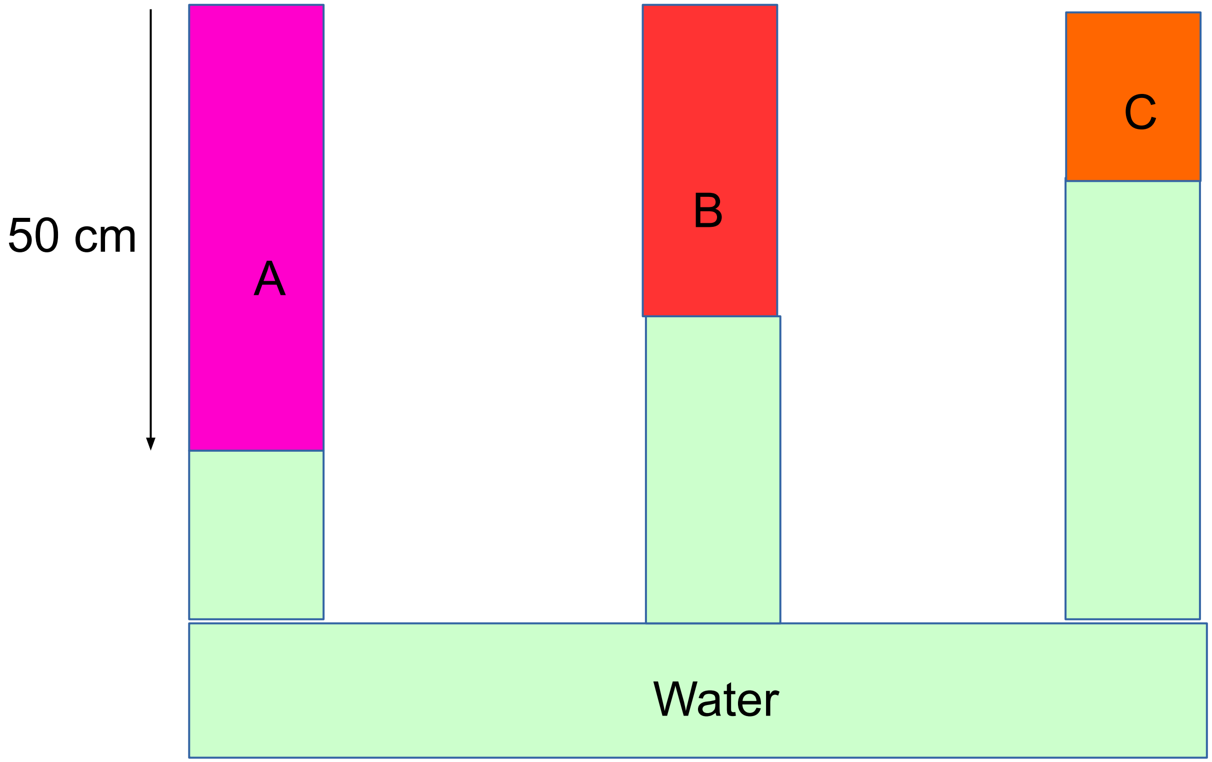
For Venus at 22.8 km, real density is about 0.1 kg/m^3, so
(4/3)*pi*4*4*4*0.1*8.87-(4/3)*pi*4*4*4*1.24*8.87= -2033N, so a=
-2033.1/((4/3)*pi*4*4*4*1.24)=-8.15 m/s^2, so vf=4560-8.15*10=4478.5 m/s;
xf=22800+4560*10-8.15*100=67585

Assuming the open U-tube shown is in equilibrium, rank the densities of the fluids, from lowest to highest, given that they are all lighter than water (ρ_{fluid}<1 g/cc). The heights of fluids are 50 cm, 40 cm and 30 cm, respectively.

A) $\rho_A > \rho_B > \rho_C$

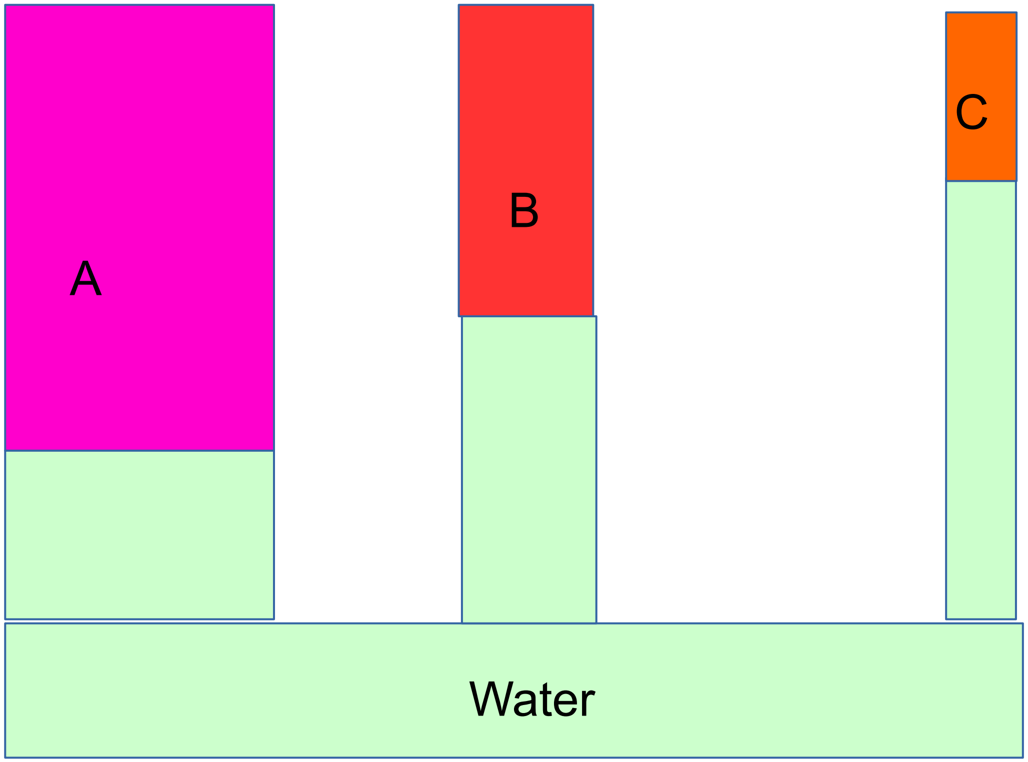
B) $\rho_A < \rho_B < \rho_C$

C) $\rho_A = \rho_B = \rho_C$

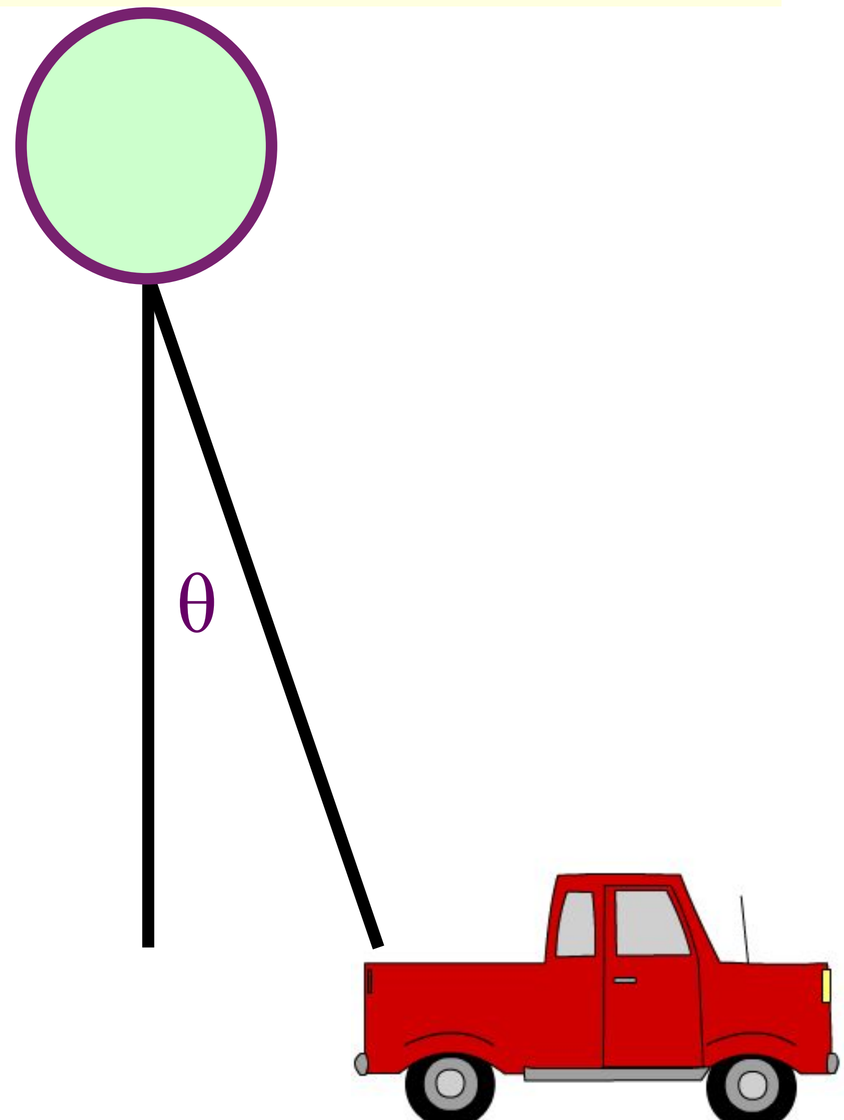


Given that $\rho_C > \rho_B > \rho_A > \rho_{water}$, what are the relative pressures at the bottom of the water trough?

A) $P_A > P_B > P_C$
B) $P_C > P_B > P_A$
C) $P_B > P_A > P_C$
D) $P_B > P_C > P_A$
E) NOTA/Need More Information



The HiCal balloon (268 ft^3 Helium-filled) is tied to a truck prior to launch. What is the angle θ in the picture if the x-acceleration is 2 m/s^2? (1 ft^3=0.02832 m^3; $\boldsymbol{\rho_{He}}$**=0.16 kg/m^3; $\boldsymbol{\rho_{air}}$=1.24 kg/m^3**)



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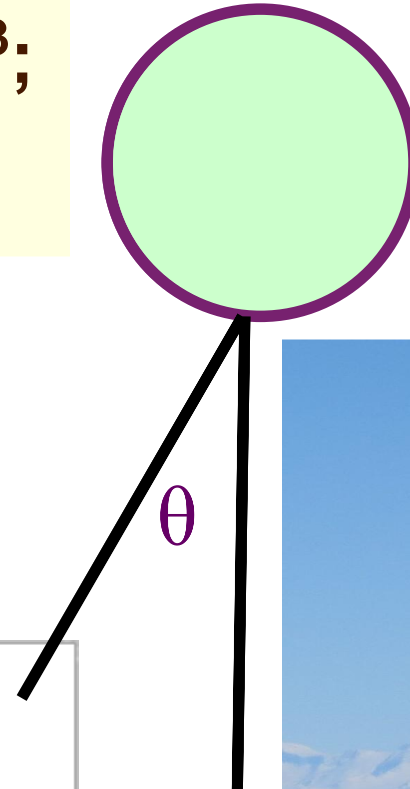
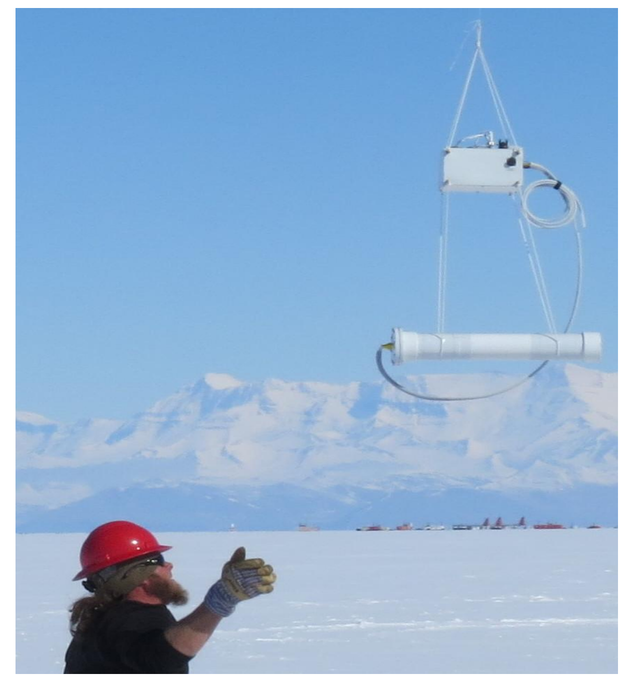




A) 88.27°

B) 2.42°

C) 30°

D) 1.73°

E) NOTA

The HiCal experiment comprises a payload hanging off a 268 ft^3 Helium-filled balloon. What is the maximum payload mass so that the balloon 'takes off'?

(1 ft^3=0.02832 m^3; **ρ_{He}=0.16 kg/m^3; ρ_{air}=1.24 kg/m^3**)

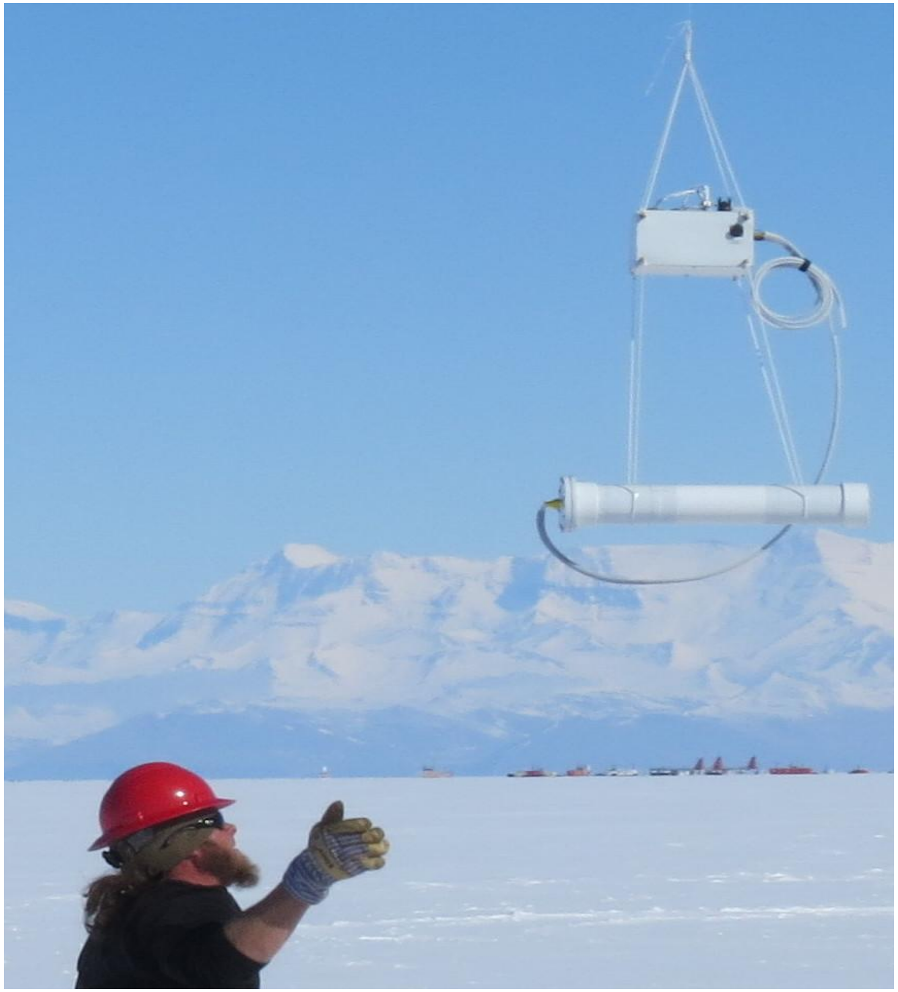
A) 80.33 kg

B) 8.196 kg

C) 4.098 kg

D) 40.98 kg

E) NOTA



As the mylar balloon ascends, which is true?

A) The net force on the balloon increases

B) The buoyancy force increases

C) The ascent rate (i.e., acceleration) increases

D) Two or more of the above are true

E) NOTA

45 balloons, each having V=8 m^3 and filled with He (ρ_{He}=0.16 kg/m^3) are tied to a lawn chair upon which a 60-kg man sits. Taking ρ_{air}=1.24 kg/m^3, what is the net F_y on Larry+balloons? (ignore LW's buoyancy)

A) 4962.7 N

B) 3222.22 N

C) 1152.5 N

D) 4374 N

E) NOTA

After 30 seconds, assuming constant acceleration, how far has Larry Waters ascended?

A) 1370 m

B) 12330 m

C) 239 m

D) 1012 m

E) NOTA

Balloons, redux:

Gas balloon: Inflated with gas of lower density than ambient atmosphere. Most gas balloons operate such that the internal pressure of the gas is the same as the pressure of the surrounding atmosphere. One special gas balloon is

Superpressure balloon: the volume of the balloon is kept relatively constant in the face of changes in the temperature of the contained lifting gas. Uses ballast

Hot air: obtains its buoyancy by heating the air inside the balloon. When heated, air expands, so a given volume of space contains less air. This makes it lighter and, if its lifting power is greater than the weight of the balloon containing it, it will lift the balloon upwards.

In a variable-volume balloon, the volume of the lifting gas changes due to heating and cooling in the diurnal cycle. The cycle is magnified by a greenhouse effect inside the balloon, while the surrounding atmospheric gas is subject to a much more limited cyclical temperature change. As the lift gas heats and expands, the displacement of atmospheric gas increases, while the balloon weight remains constant. Its buoyancy increases, and this leads to a rise in altitude unless it is compensated by venting gas. Conversely, if the balloon cools and drops, it becomes necessary to release ballast. Since both ballast and gas are finite, there is a limit to how long a variable-volume balloon can compensate in order to stabilize its altitude. In contrast, a superpressure balloon will change altitude much less without compensation maneuvres.

So the force pushing the balloon upwards diminishes with altitude and at some particular altitude the upwards force will equal the weight of the balloon: the balloon will be stable in a finite equilibrium altitude range for long periods.

Moving fluids

Primary principle: Bernouilli Equation for fluid with mass m moving forced between points 1->2:

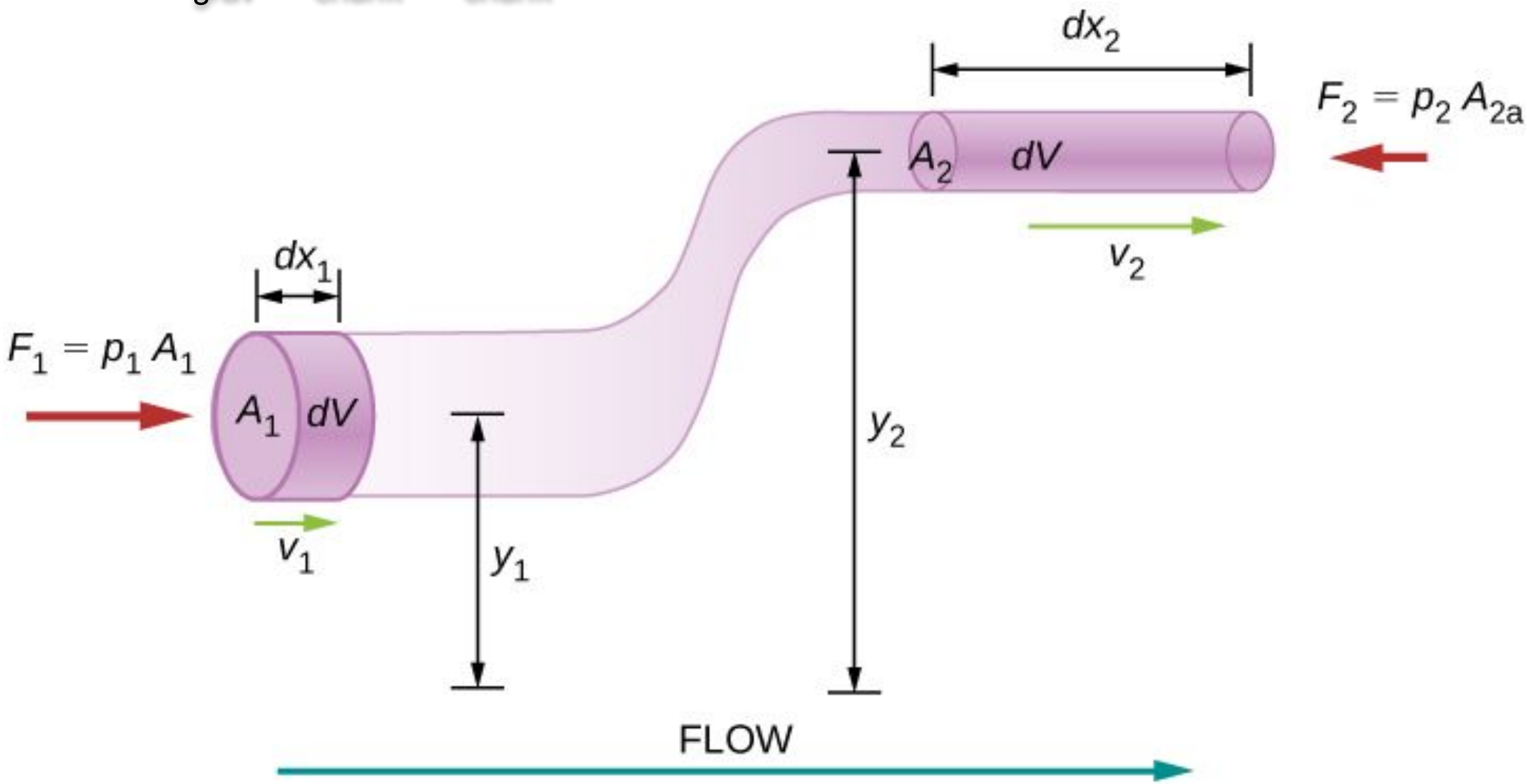
$W_{ext}=\Delta KE+\Delta PE$+heat, zero heat here, so $(P_1Ad-P_2Ad)=(\frac{1}{2}mv_2^2-\frac{1}{2}mv_1^2)+(mgh_1-mgh_2)$, dividing by Ad==Volume

For fluid chunk moving up along some incline from pt. 1 to pt. 2, then:

$W_{ext}(1\text{->}2)+W_{grav}(1\text{->}2)=\frac{1}{2}mv_2^2-\frac{1}{2}mv_1^2$, external force is net force of fluid to left of chunk vs. force of fluid to the right of chunk. $W_{grav}(1\text{->}2)=PE_1-PE_2$

ın the diagram below, which formula expresses the relationship between the gravitational work done by the fluid external to it, and the change in gravitational PE of the fluid superchunk as it moves from y_1 to y_2, taking into account the sign of W_{grav}?

A) $W_{grav}=\rho_{chunk}gV_{chunk}(y2-y1)$
B) $W_{grav}=\rho_{chunk}gV_{chunk}(y1-y2)$



<u>**Moving fluids**</u>

Primary principle: Bernouilli Equation (restatement of work-kinetic energy theorem!), compares pressure and velocity of fluid at two different points in a moving fluid:

$$\rho_1 g h_1 + \tfrac{1}{2}\rho_1 v^2{}_1 + P_1 = \rho_2 g h_2 + \tfrac{1}{2}\rho_2 v^2{}_2 + P_2$$

OR:

$$(P_2 - P_1) = (\rho_1 g h_1 + \tfrac{1}{2}\rho_1 v^2{}_1) - (\rho_2 g h_2 + \tfrac{1}{2}\rho_2 v^2{}_2)$$

If $h_2 = h_1 \Rightarrow W = \Delta KE$ (careful: in Work-KE theorem, $W = W_{tot}$; here, $W_{tot} = W_{surrounding\ fluid} + W_{grav} = (\rho g (h_2 - h_1) V)$

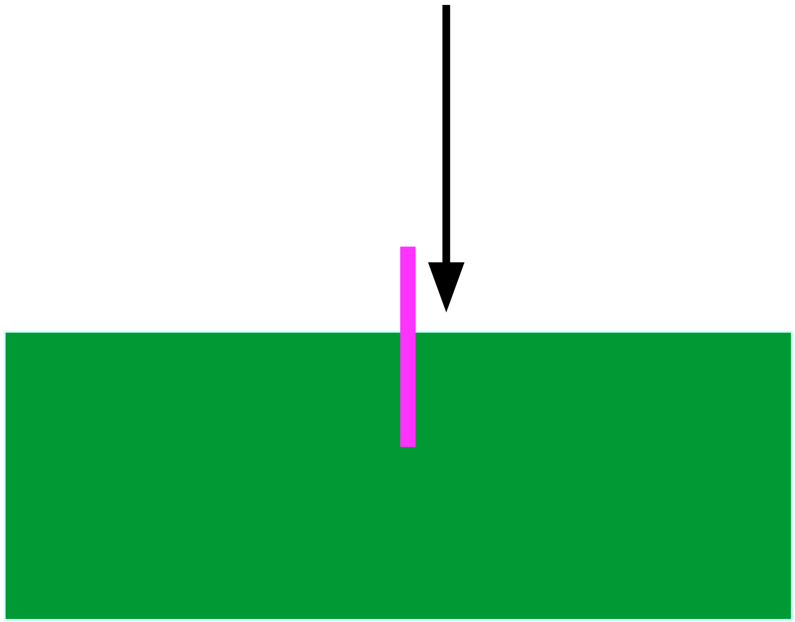
Water is flowing through the pipe shown. If a magenta metal plate is inserted halfway into the pipe, which of the following quantities increase?

A) The pressure in the fluid just in front of (but not going around) the plate

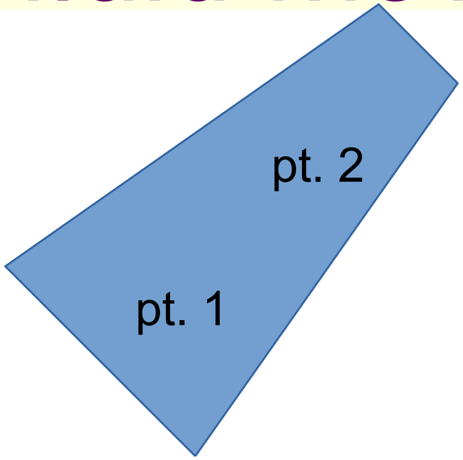
B) The pressure in the fluid going around the plate

C) Both A&B

D) Neither A or B



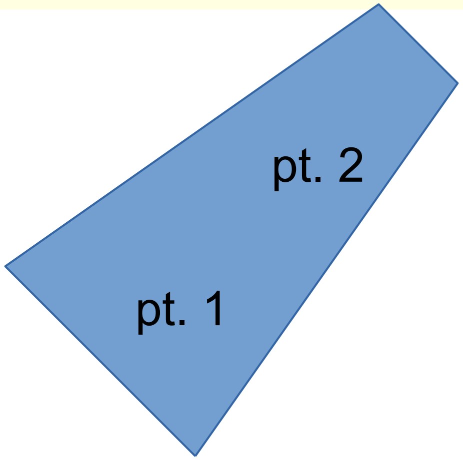
Fluid moves up through the tube shown. Which expression best describes conservation of energy, as the fluid moves?



A) $P_1 - P_2 \sim (K.E._{fluid,\ pt.\ 2} - K.E._{fluid,\ pt.\ 1}) + PE_2 - PE_1$

B) $P_2 - P_1 \sim (K.E._{fluid,\ pt.\ 2} - KE_{fluid,\ pt.\ 1}) + PE_2 - PE_1$

Fluid moves up through the tube shown. Which statements are true?



A) $P_1 > P_2$; $v_1 > v_2$
B) $P_1 > P_2$; $v_1 < v_2$
C) $P_1 < P_2$; $v_1 > v_2$
D) $P_1 < P_2$; $v_1 < v_2$
E) NOTA

Water flows through a "square" cross-section conduit. Rank the three points from lowest to highest pressure

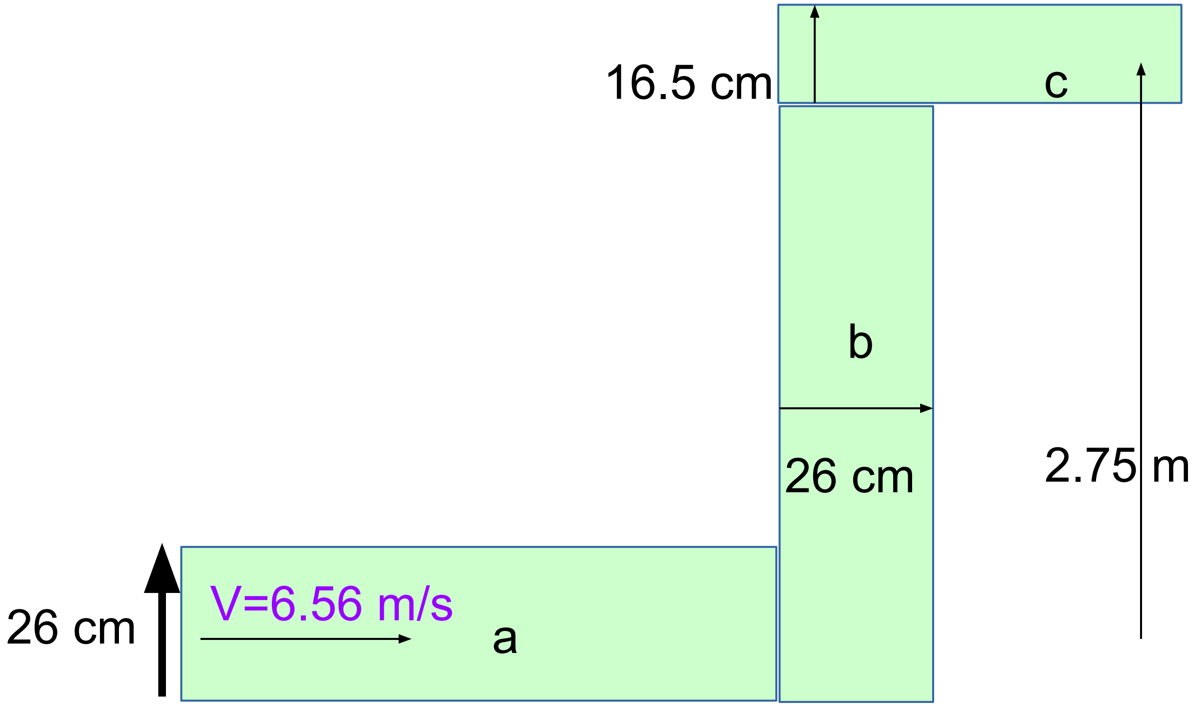
A) $P_a = P_b = P_c$

B) $P_a < P_b < P_c$

C) $P_a > P_b > P_c$

D) $P_a > P_c > P_b$

E) NOTA



If the pressure in the water at the opening is 1.65 x 10^5 Pa, what is the pressure at the exit point c? (Calculate velocities first!)

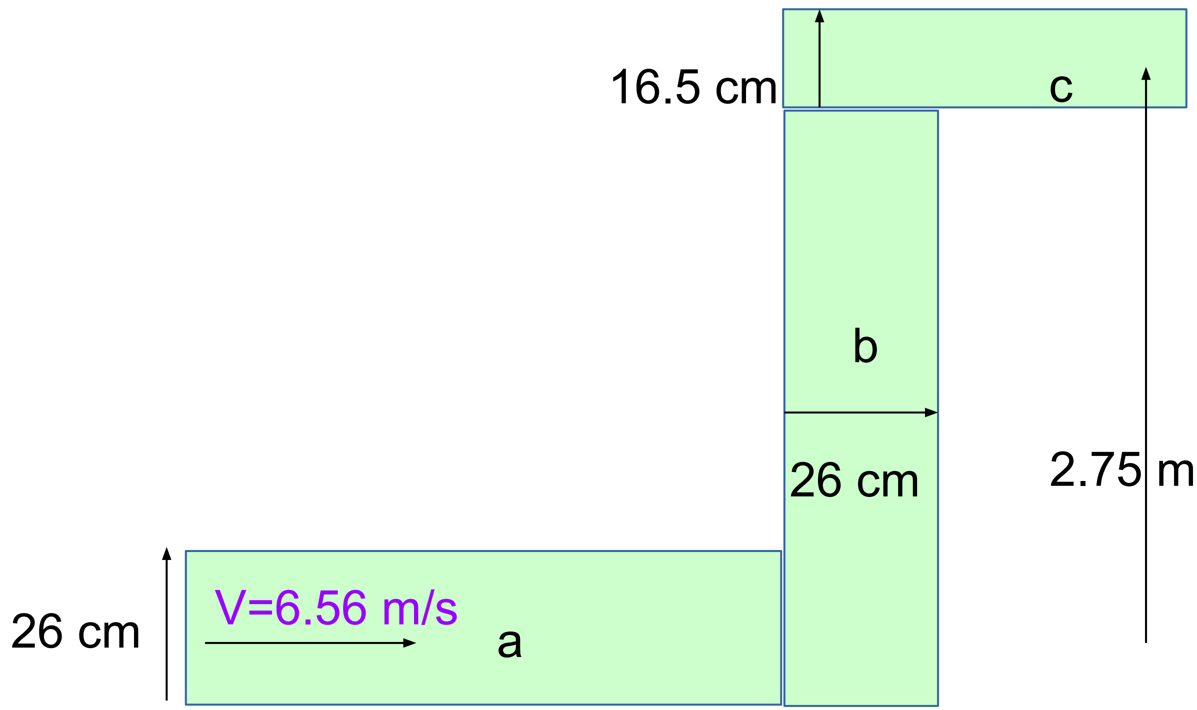
A) 106140 Pa

B) 159360 Pa

C) 27047 Pa

D) 101330 Pa

E) NOTA



If the water were replaced with a denser fluid, then the pressure at the exit point would:

A) Increase

B) Decrease

C) Be unchanged

If the dimensions of the pipe at the bottom and the top were both doubled, but all the other parameters unchanged, the pressure at the top would:

A) Double

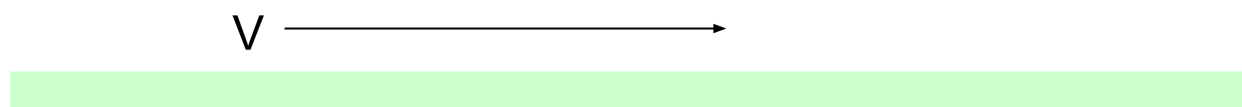
B) Quadruple

C) Be unchanged

D) Decrease by 2

E) Decrease by 4

What is the velocity of air (ρ=1.24 kg/m^3) needed to lift a 20m x 20m x 2.5cm wooden roof (ρ=ρ_{water}/4), assuming the air is still inside (NB: you only need ΔP in this problem, so needn't include P_{atm} explicitly.) (Aside: average windspeed in Lawrence, KS is around 5-6 m/s)



A) 9.94 m/s

B) 8.87 m/s

C) 10.27 m/s

D) 11.75 m/s

E) NOTA

In the previous problem, which of the following would result in a lower minimum windspeed?

A) Higher density roof

B) Velocity non-zero inside

C) Higher air density

D) Two of the above

E) NOTA

Given the two houses below; assuming the TOTAL roof mass is the same in both cases, and the surface area of each inclined side of the A-frame is the same as the flat roof in B, which is more stable in a tornado?

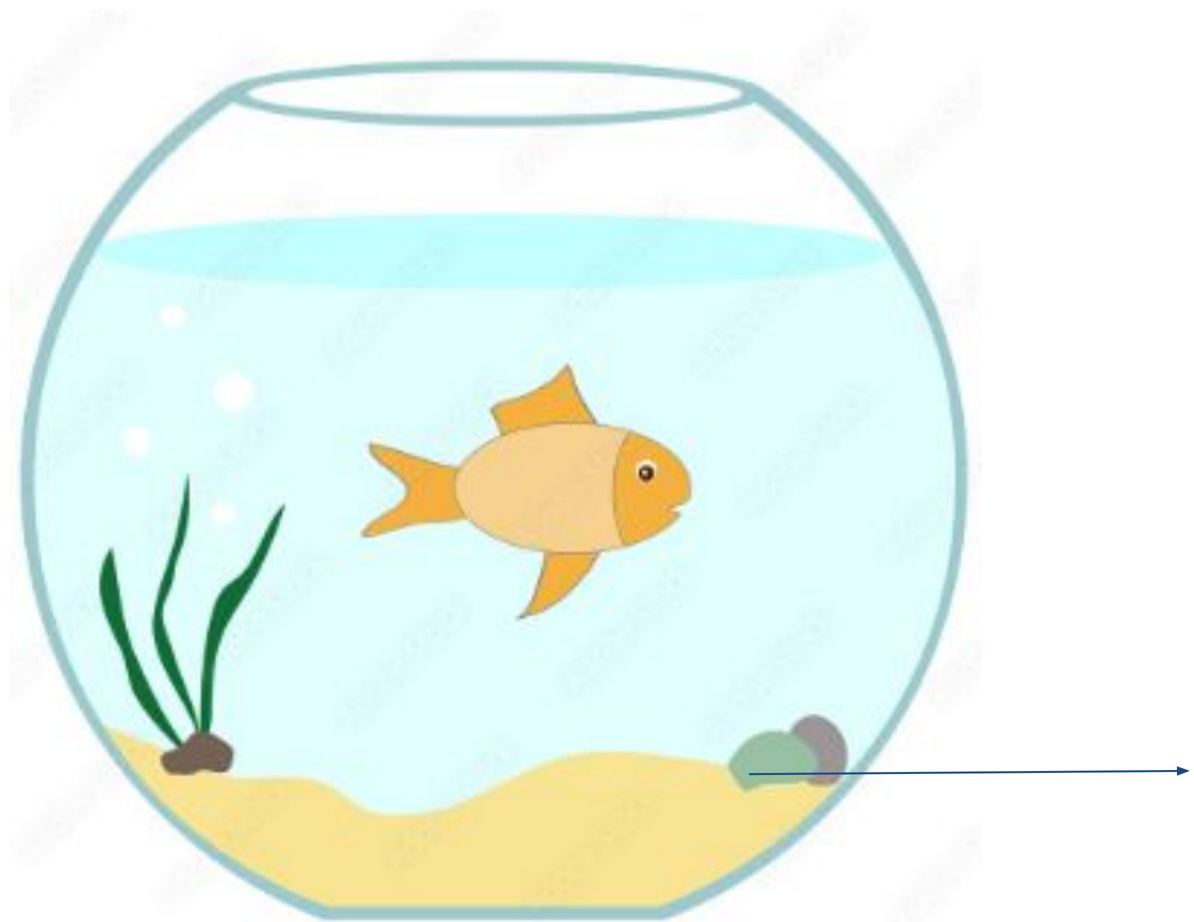
A) A

B) B

C) Equally stable

Country Joe Fish, realizing that he has been condemned to a life of aquatic imprisonment, decides to bust out, and pops a hole in the bottom of his 1.02 m deep aquarium. Which is true of the velocity of the fluid as it exits compared to the velocity of the fluid layer near the top?

A) $v_{top} >> v_{hole}$
B) $v_{top} << v_{hole}$
C) $v_{top} \sim v_{hole}$



Country Joe Fish, realizing that he has been condemned to a life of aquatic imprisonment, decides to bust out, and pops a hole in the bottom of his 1.02 m deep aquarium. How fast does the water flow out of his aqueous prison (approximate the water at the top to be close to at rest)?

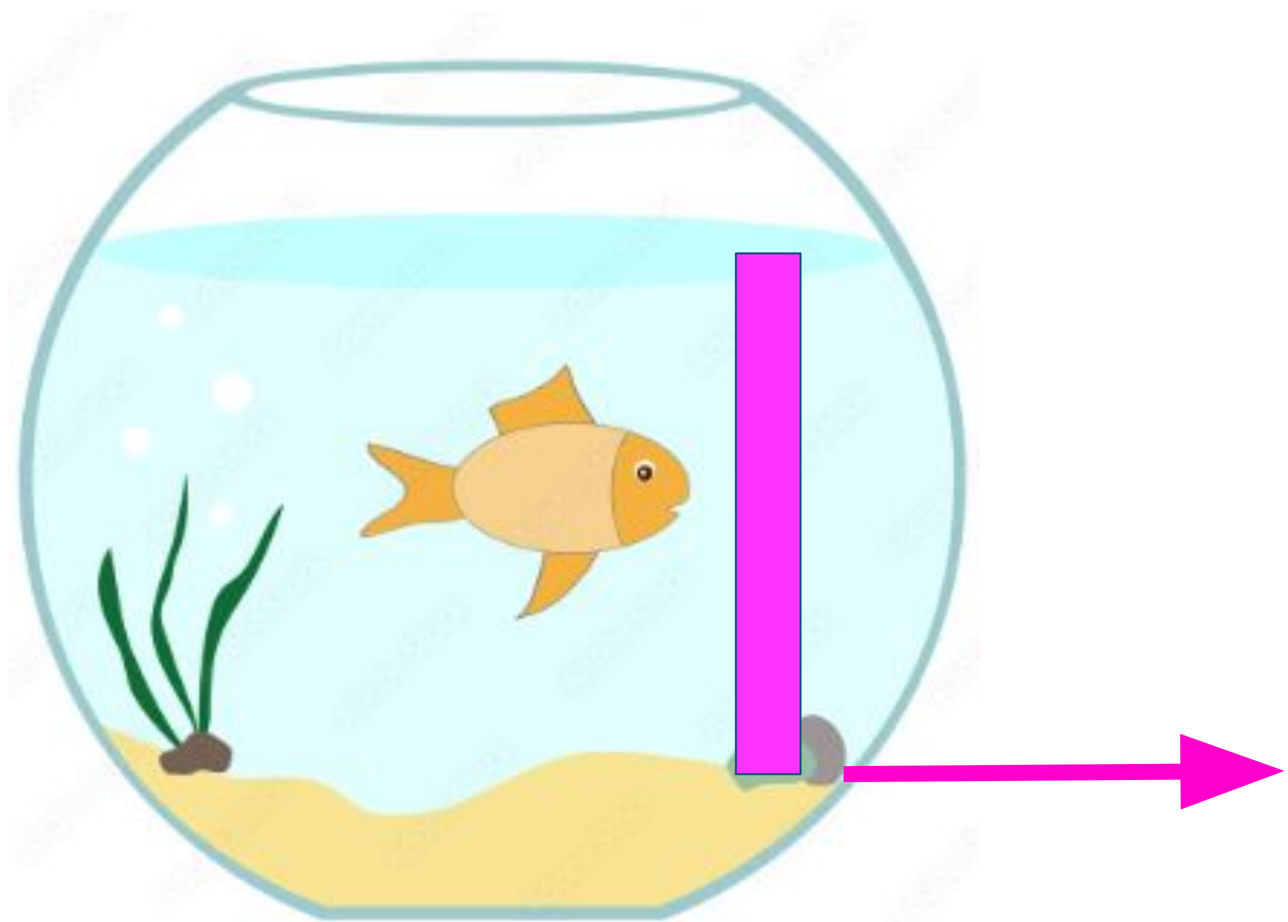
A) 1 cm/s

B) 10 cm/s

C) 4.47 m/s

D) 3.16 m/s

E) NOTA

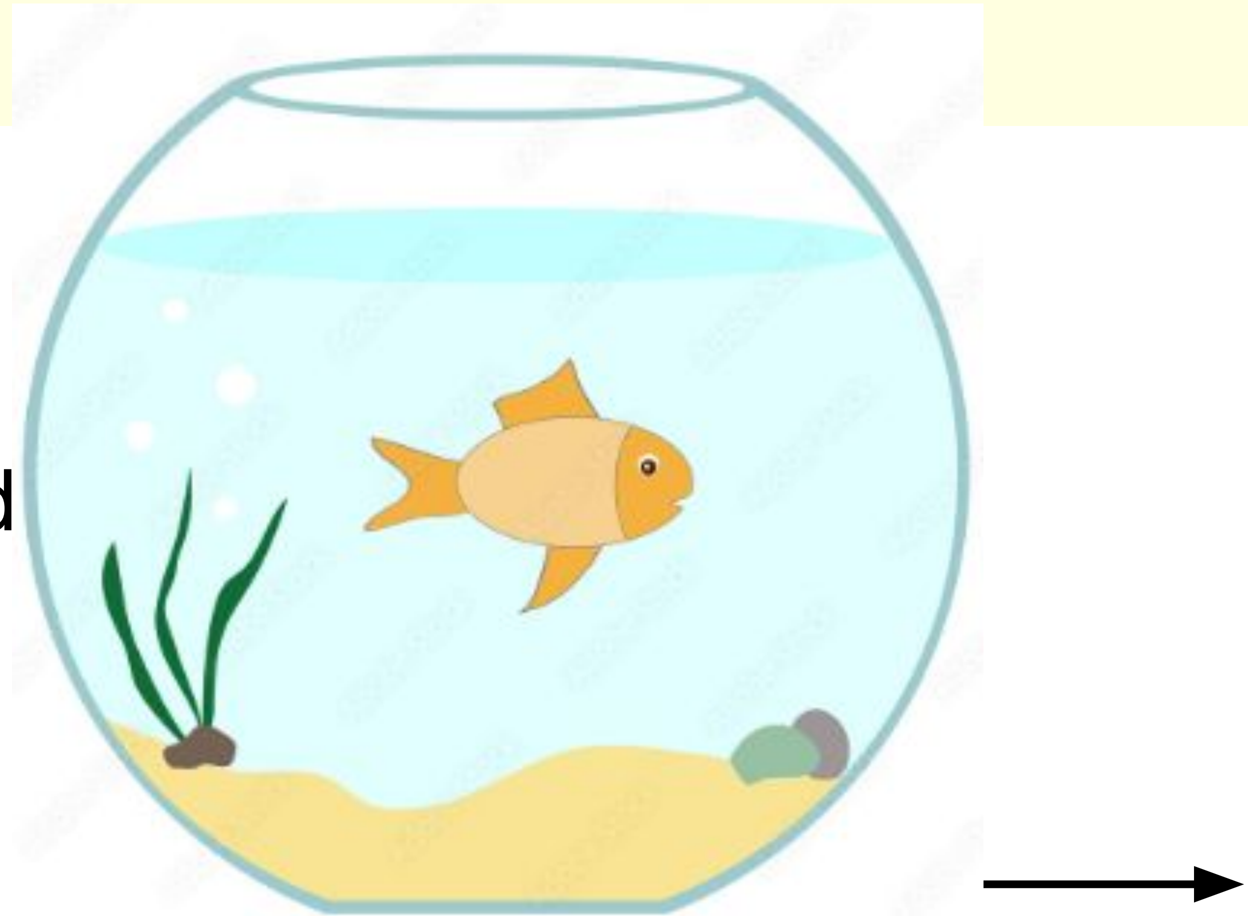


Now taking into account the fact that the velocity at the top of the aquarium is non-zero, the actual velocity, compared to what you just calculated, is:

A) smaller

B) larger

C) Unchanged



A fluid, having viscosity η, is moving through a pipe of length L and width w; a pressure P "drives" the fluid through the pipe. Which of the following best relate the fluid velocity v to the parameters above?

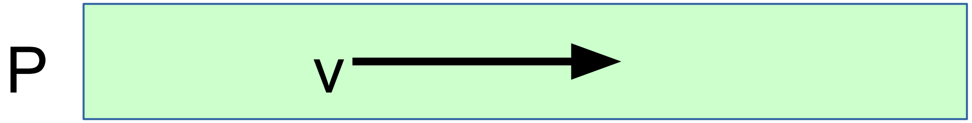
A) $v \sim PL/(w\eta)$

B) $v \sim PLw/\eta$;

C) $v \sim L\eta/Pw$

D) $v \sim Pw/\eta L$

E) NOTA



cylindrical pipe filled with water, at top r=2 cm, h=3 m, v=10 m/s, P=50 kPa; at bottom, r=6 cm Find pressure at bottom:
0.5*1000*10*10+1000*9.8*3+50000=0.5*1000*1.11*1.11+P(bottom), so P(bottom)=0.5*1000*10*10+1000*9.8*3+50000-0.5*1000*1.11*1.11= 128783 Pa - pressure has increased for two reasons: mgh and also lower velocity!
NB: if water flowing up, make sure that pressure is high enough to get fluid to top!

Thermodynamics

$U=3/2\ Nk_BT$ in 3-dimensions for spherical gas particles (so, at endpoints of given path, $\Delta U=(3/2)P_fV_f-P_iV_i$); $k_B=1.38\times10^{-23}$ J/K

$\Delta Q=W_{\text{done by system}} + \Delta U + Q_{\text{environment (waste)}}$; i.e., heat absorbed in shows up as particles moving faster + expansion of volume + waste heat. $\varepsilon=W_{out}/Q_{absorbed}$ - for $Q_{waste}=0$, $\varepsilon=1$

for Carnot ***(reversible)*** cycle $=1-T_L/T_H$;

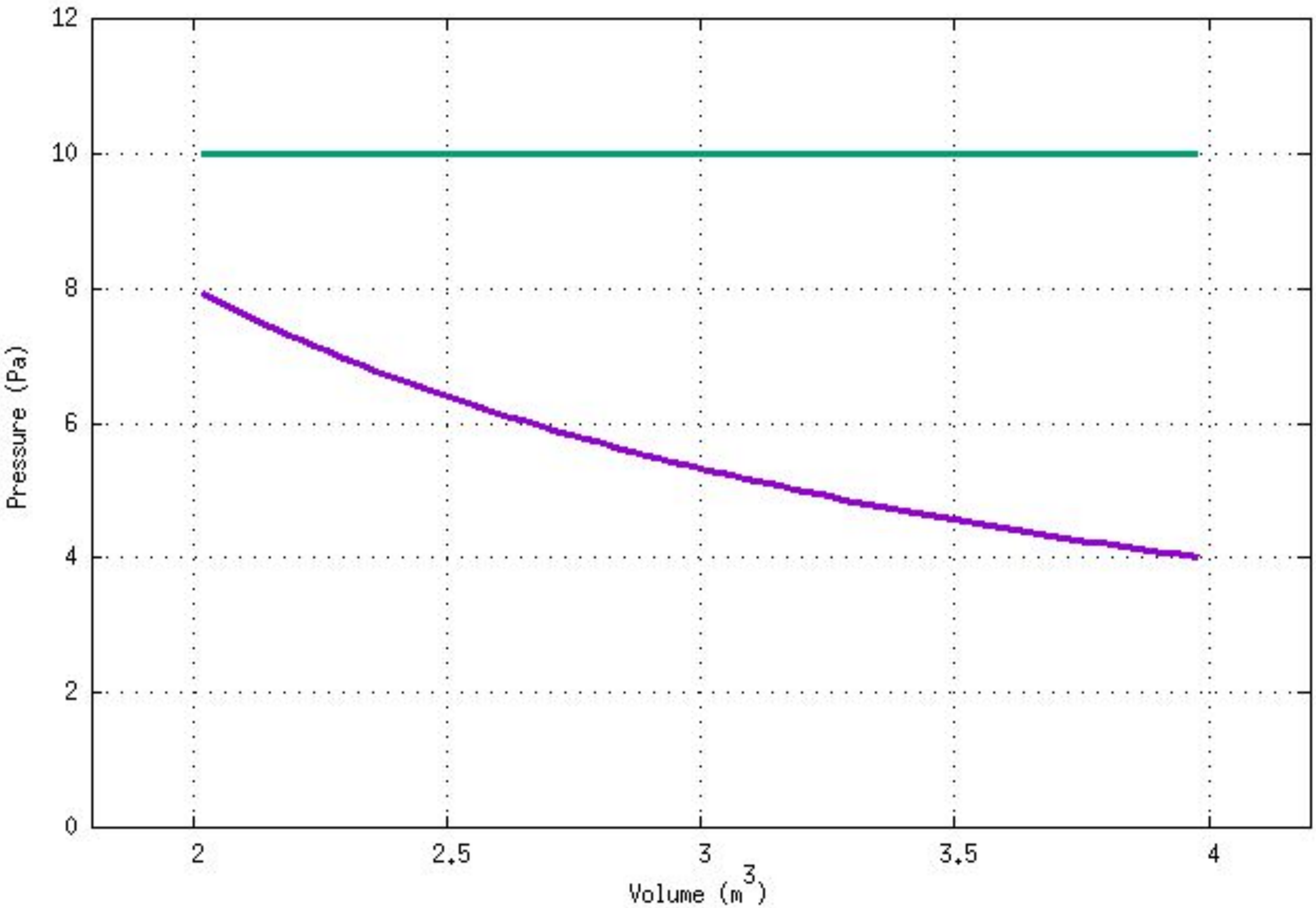
$S=\Delta Q/T$

CAUTION: $W_{\text{done by system}}=-W_{\text{done on system}}$

Efficiency for a reversible cycle is 1 assuming Q_{waste}=0. In addition to heat lost to the environment, Q_{waste} includes the heat lost from the high temperature portion of the cycle to the low temperature portion of the cycle, which cannot show up as work. Real Carnot cycle includes this heat transfer explicitly.

https://openstax.org/books/college-physics/pages/15-3-introduction-to-the-second-law-of-thermodynamics-heat-engines-and-their-efficiency

CAP35: m=4 kg, v_f=8 m/s, so W_{done}=128 J. Now draw PV-diagram, as shown, corresponding to W approximately 10 J, so N=12

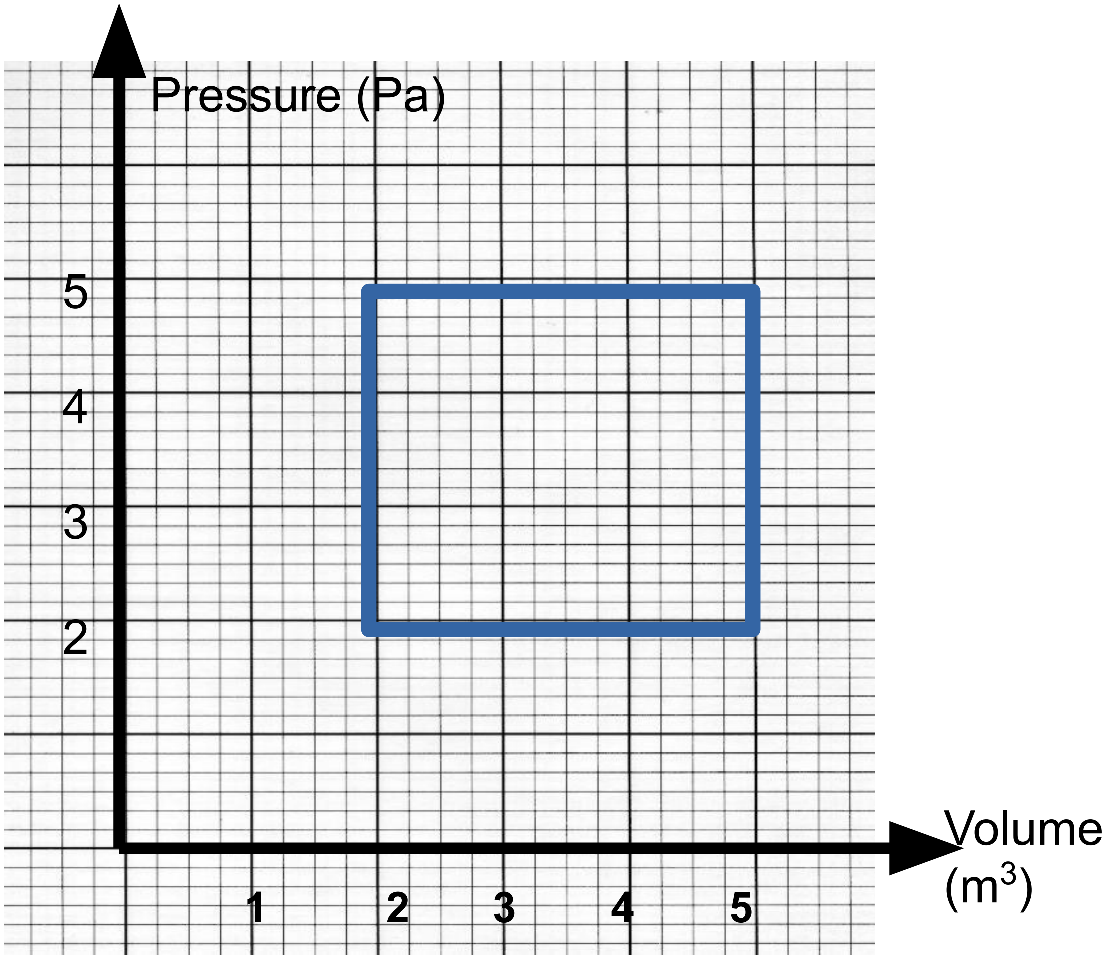


Gas in a closed volume, initially at high pressure, is allowed to expand without exchanging heat with the environment or losing waste heat.. As it does, the temperature of the gas (refer to $\Delta Q = W_{\text{done by system}} + \Delta U$)

A) Increases
B) Decreases
C) Remains constant

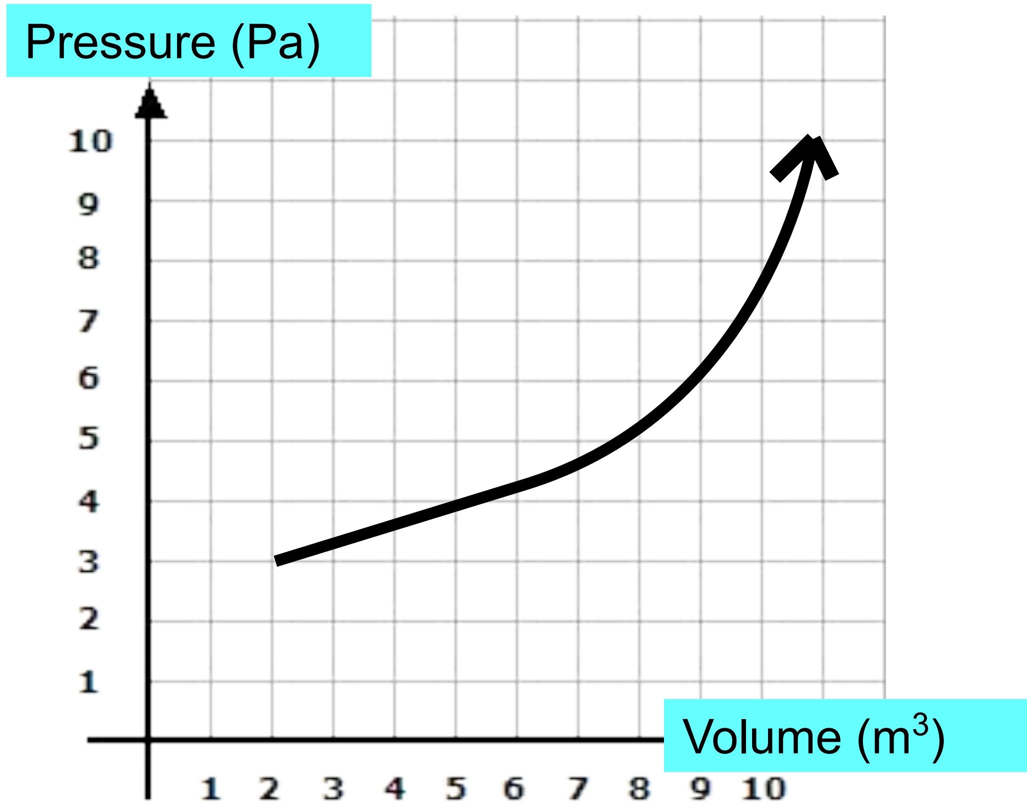
Given the PV-cycle shown for an ideal gas. If it starts at (x,y)=(5 m^3,5 Pa) and proceeds counter-clockwise, in the first step, which is true?

A) T increases, $W_{done}>0$
B) T increases, $W_{done}<0$
C) T decreases, $W_{done}>0$
D) T decreases, $W_{done}<0$
E) NOTA

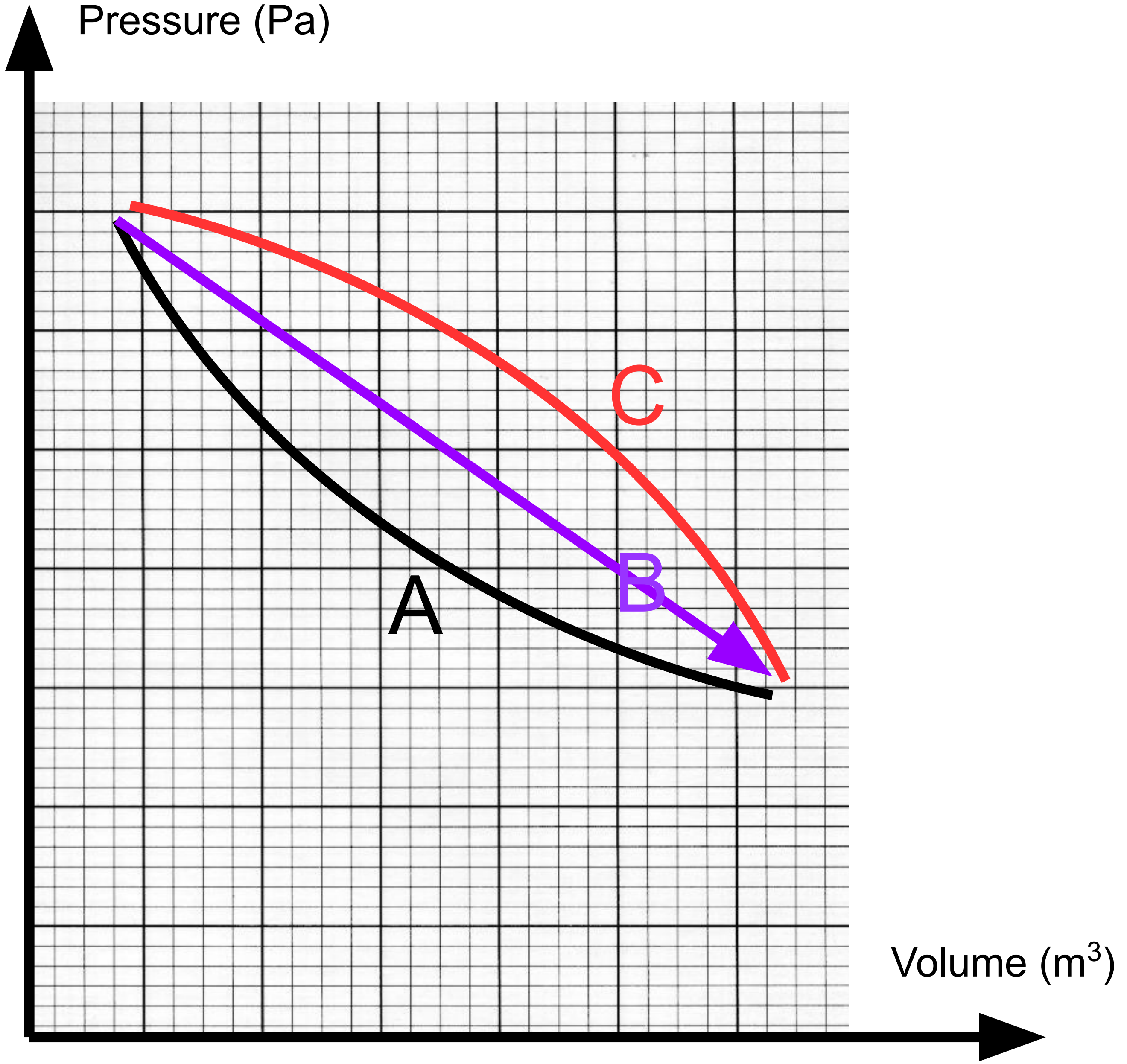


The total work done by the system during the process shown is closest to:

A) 100 J
B) 6 J
C) 80 J
D) 20 J
E) 50 J



Assuming systems evolve from left→right, which corresponds to a larger ΔQ from i→f ? (Assume ε is same for all three curves)



Rank the processes shown in terms of the magnitude of W_{done}

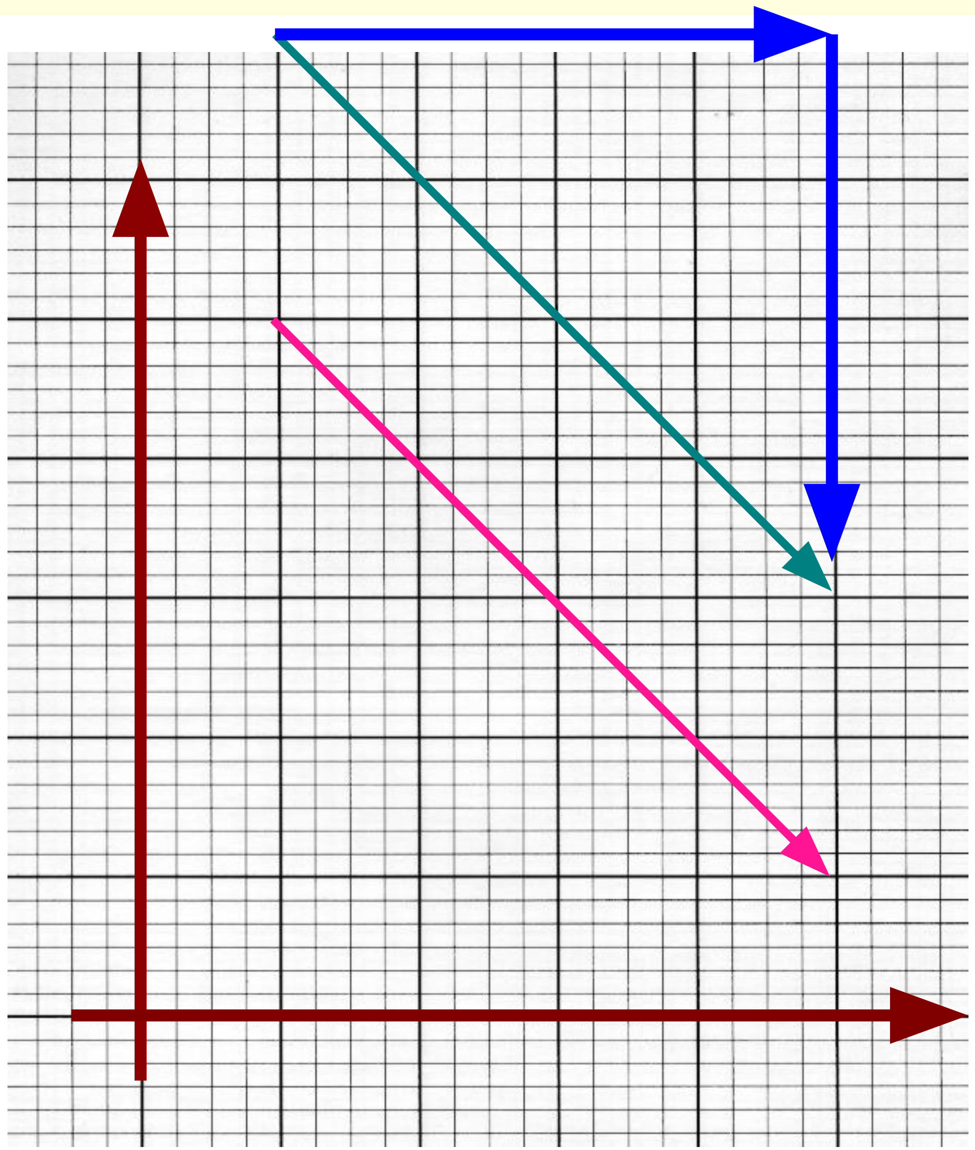
A) $W_{blue} > W_{red} > W_{green}$

B) $W_{blue} > W_{green} > W_{red}$

C) $W_{blue} < W_{red} < W_{green}$

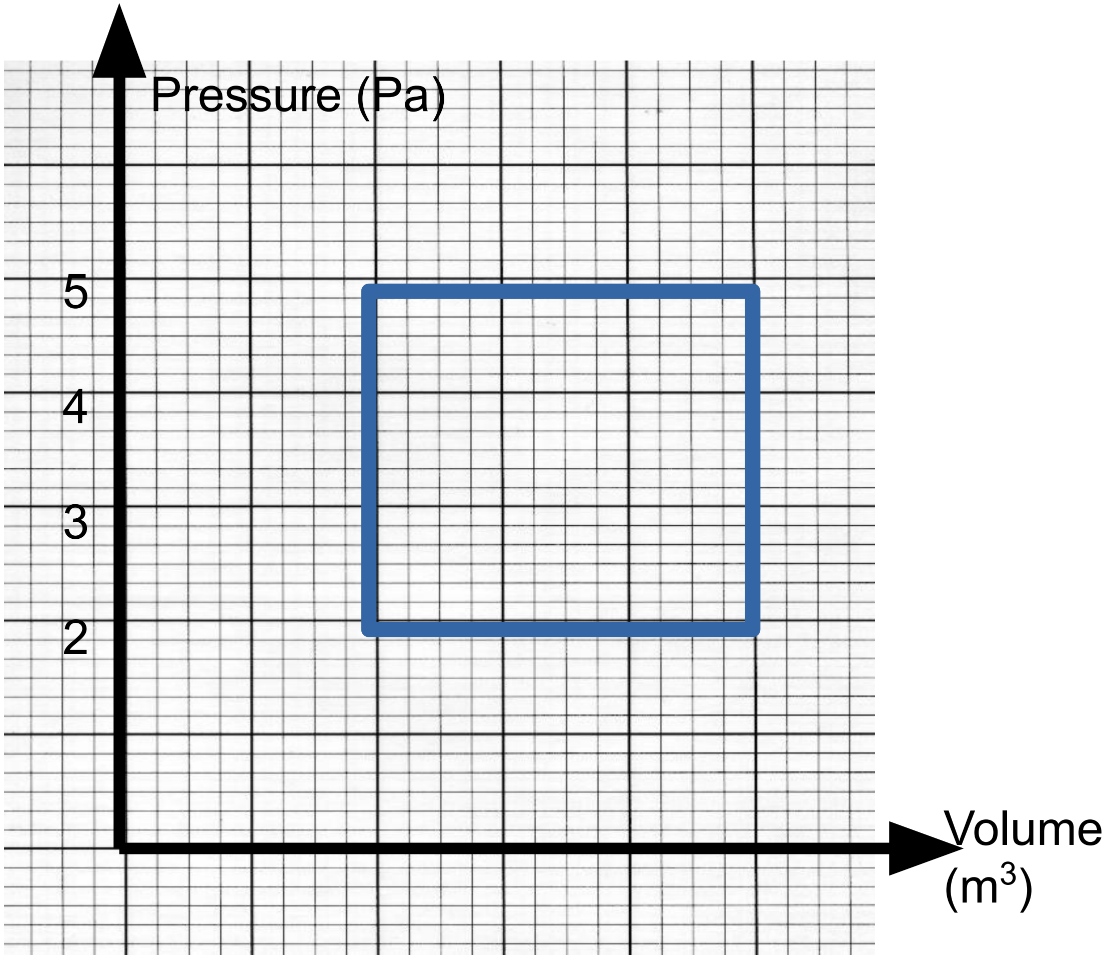
D) $W_{blue} < W_{green} < W_{red}$

E) NOTA



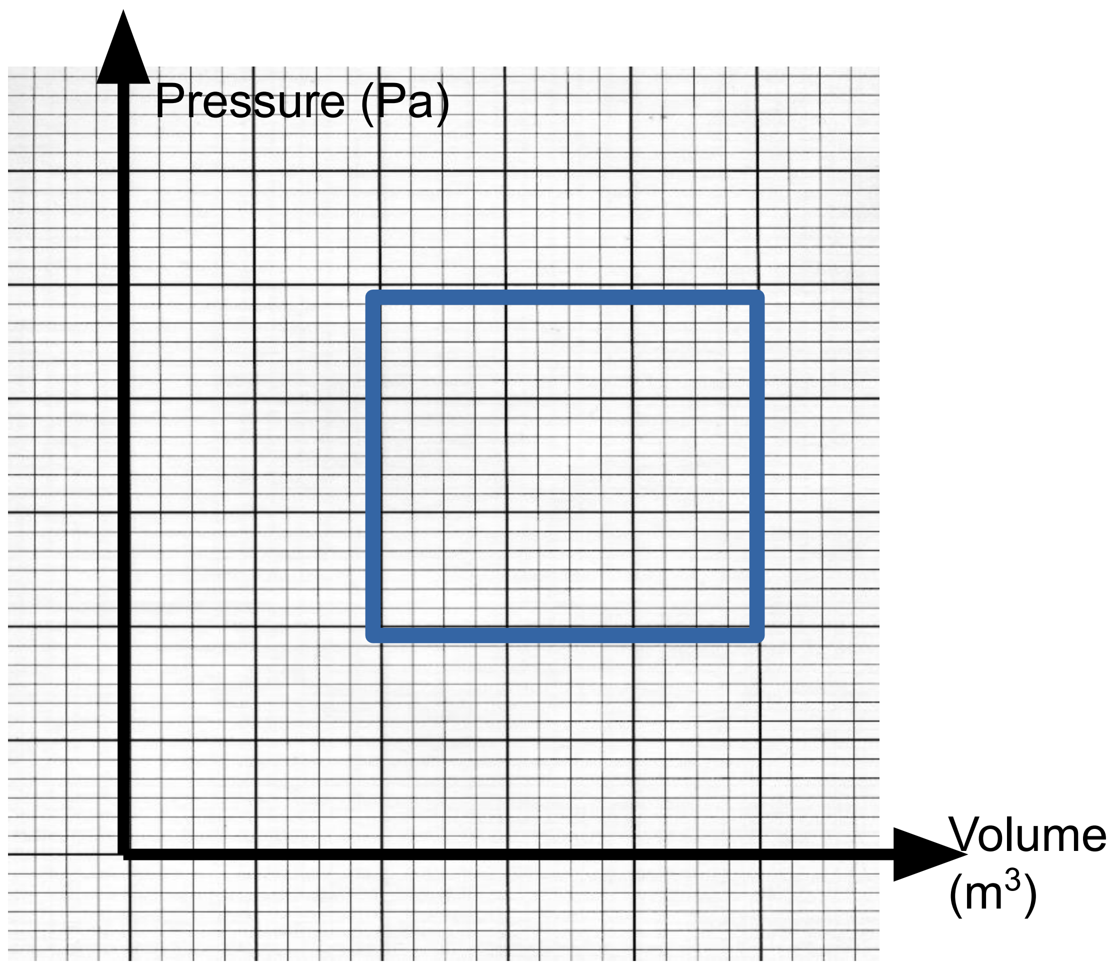
Given the PV-cycle shown for an ideal gas. If it starts at (x,y)=(5 m^3,5 Pa) and proceeds counter-clockwise, the total amount of work done, over the entire cycle, is:

A) 15 J
B) -9 J
C) 9 J
D) -15 J
E) NOTA



Given the PV-cycle shown for an ideal gas. If you know the cycle proceeds clockwise and has ε=¼ (strictly, not true, since ΔU=0 over cycle so W=Q), the total amount of heat put into the system, over the entire cycle, is:

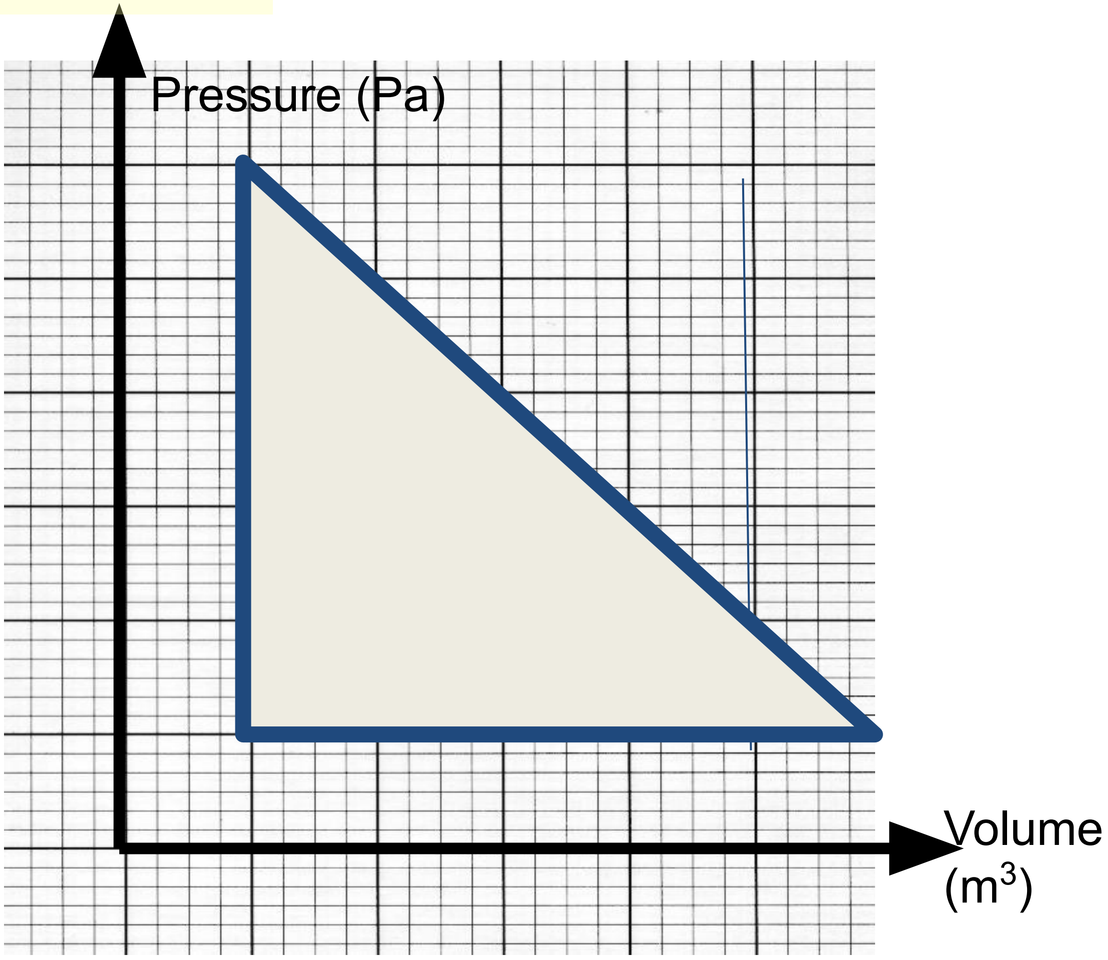
A) 15 J
B) -9 J
C) 36 J
D) 60 J
E) NOTA



Start at lower right and work cc. Verify that $\Delta U=0$ over entire cycle and calculate total W_{done}

Leg 1: W_{done}=-17.5 J; $\Delta U=0$;
Leg 2: W_{done}=0; $\Delta U=(3/2)(6*1-1*1)=-7.5$ J
Leg 3: W_{done}=+5 J; $\Delta U=(3/2)(6*1-1*1)=7.5$ J

Aside: W> or W<0 just depends on whether final volume is greater or less than initial volume!



Given the thermal cycle, with “start”=(4 m^3, 2000 Pa) and PV=constant in step 2), which is true?

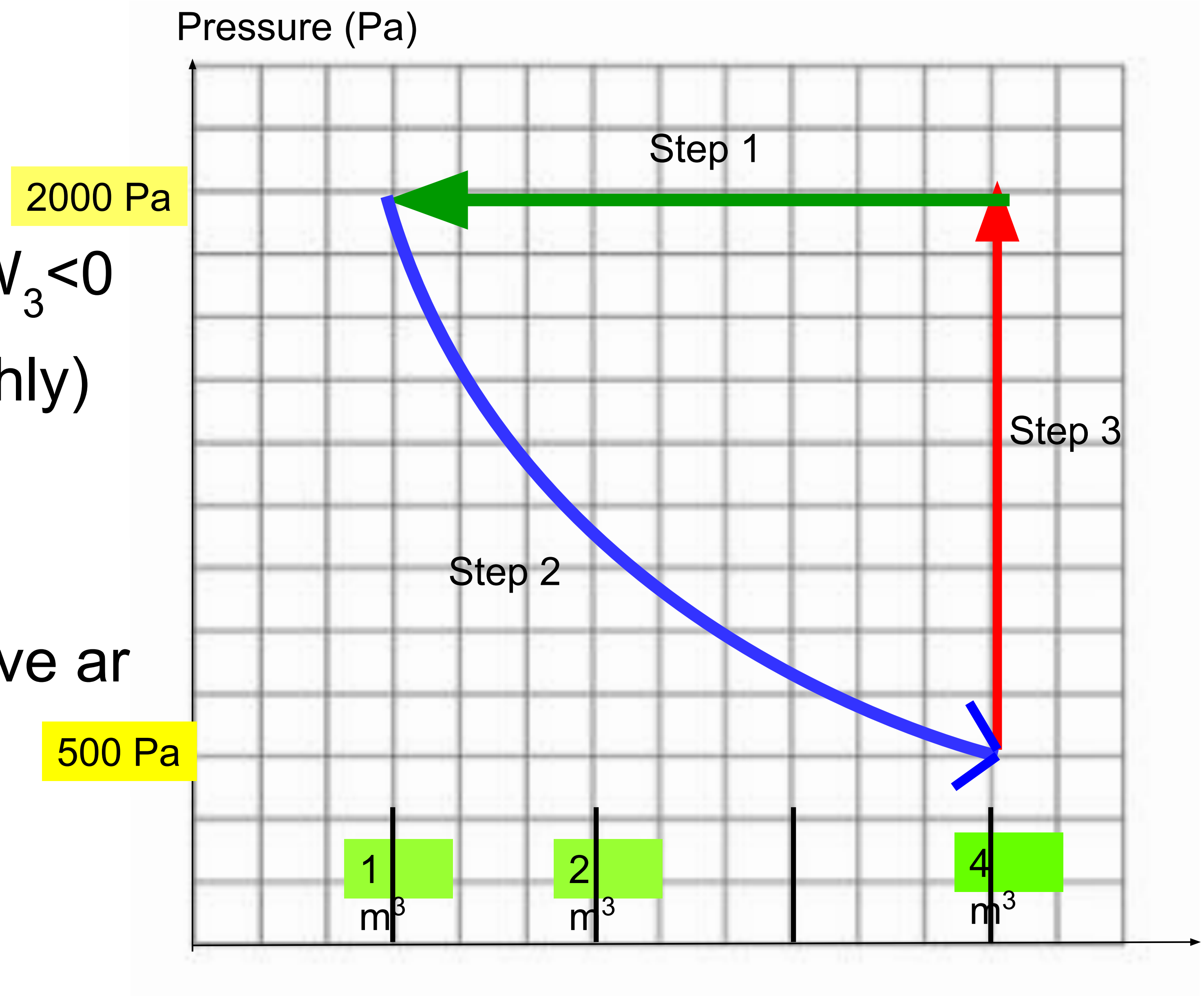
A) $W_1>0$, $W_2>0$, $W_3<0$

B) Step 2 is (roughly) an isotherm

C) $\Delta Q_1<0$

D) Two of the above ar true

E) NOTA

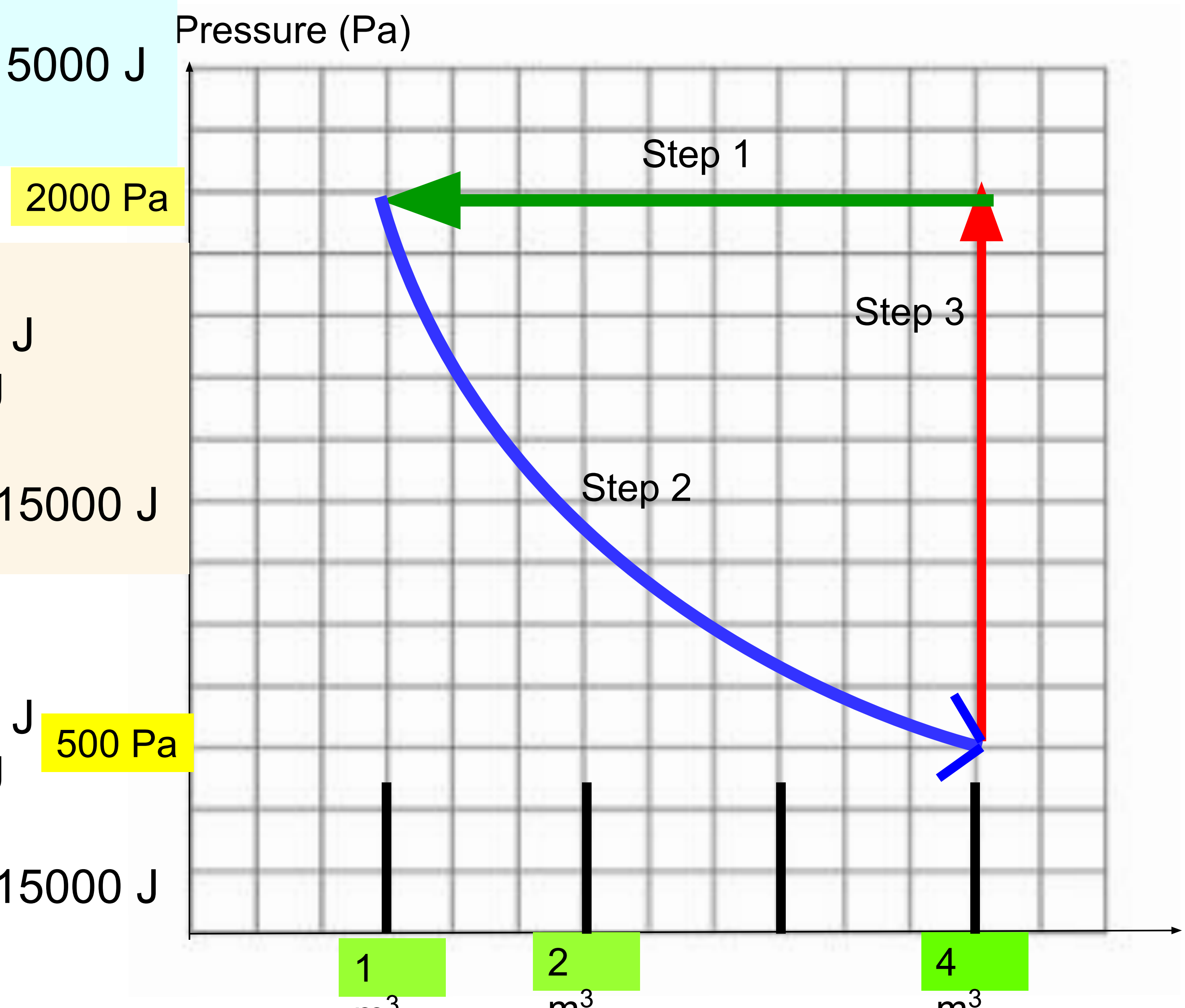


In Step 1, what are W_{gas}, ΔU_{gas}, and $\Delta Q_{applied}$?

A) -2000 J, +9000J, -11000 J
B) 10J, 15J, 25 J
C) -10 J, -15J, -25 J
D) -6000 J, -9000 J, -15000 J
E) NOTA

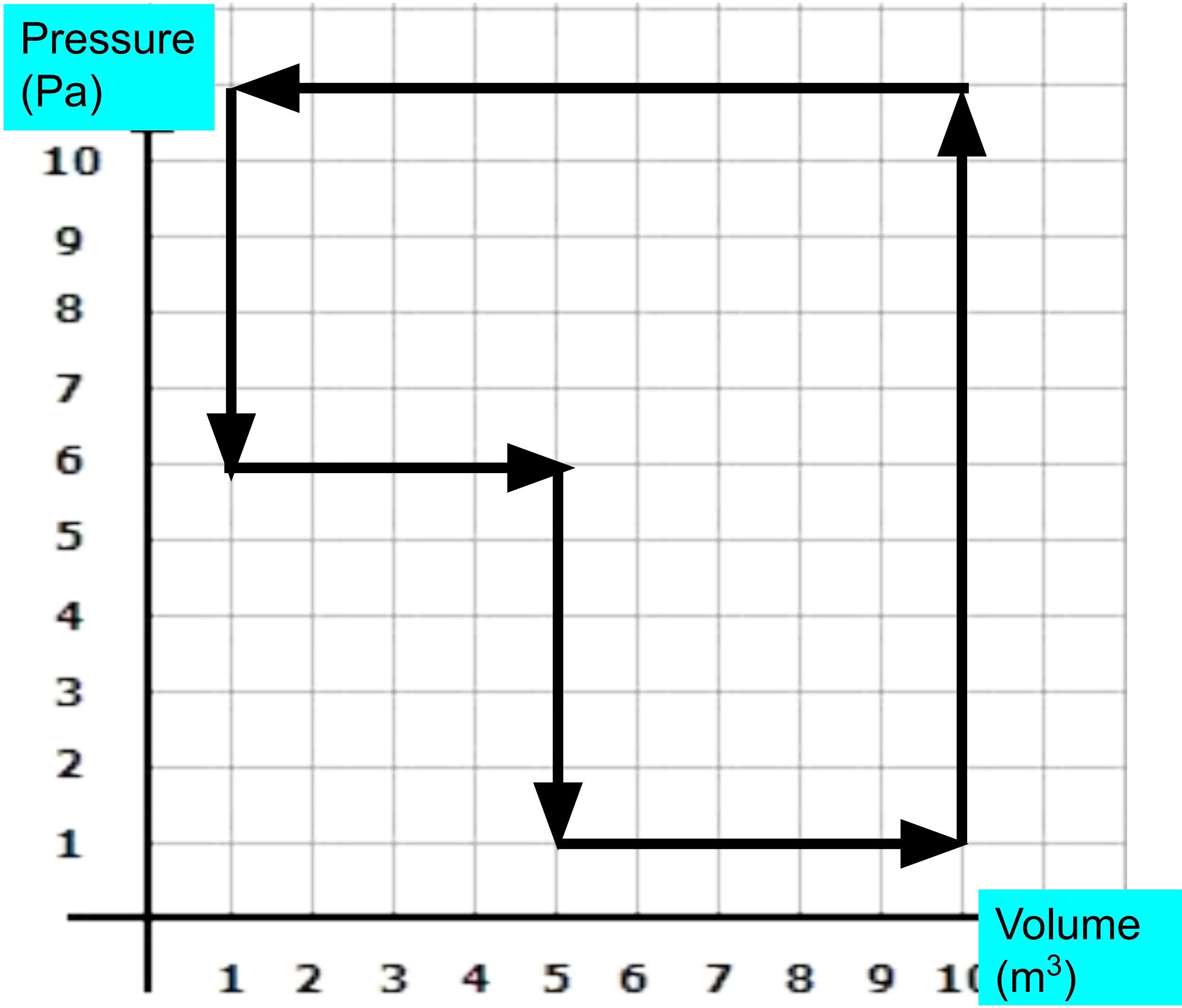
Step 2:
A) -2500 J, +2500J, 0 J
B) 3500 J, 0 J, 3500 J
C) -10 J, -15J, -25 J
D) -6000 J, -9000 J, -15000 J
E) NOTA

Step 3:
A) -2500 J, +2500J, 0 J
B) 2500 J, 0 J, 2500 J
C) 0J, 9000J, 9000 J
D) -6000 J, -9000 J, -15000 J
E) NOTA



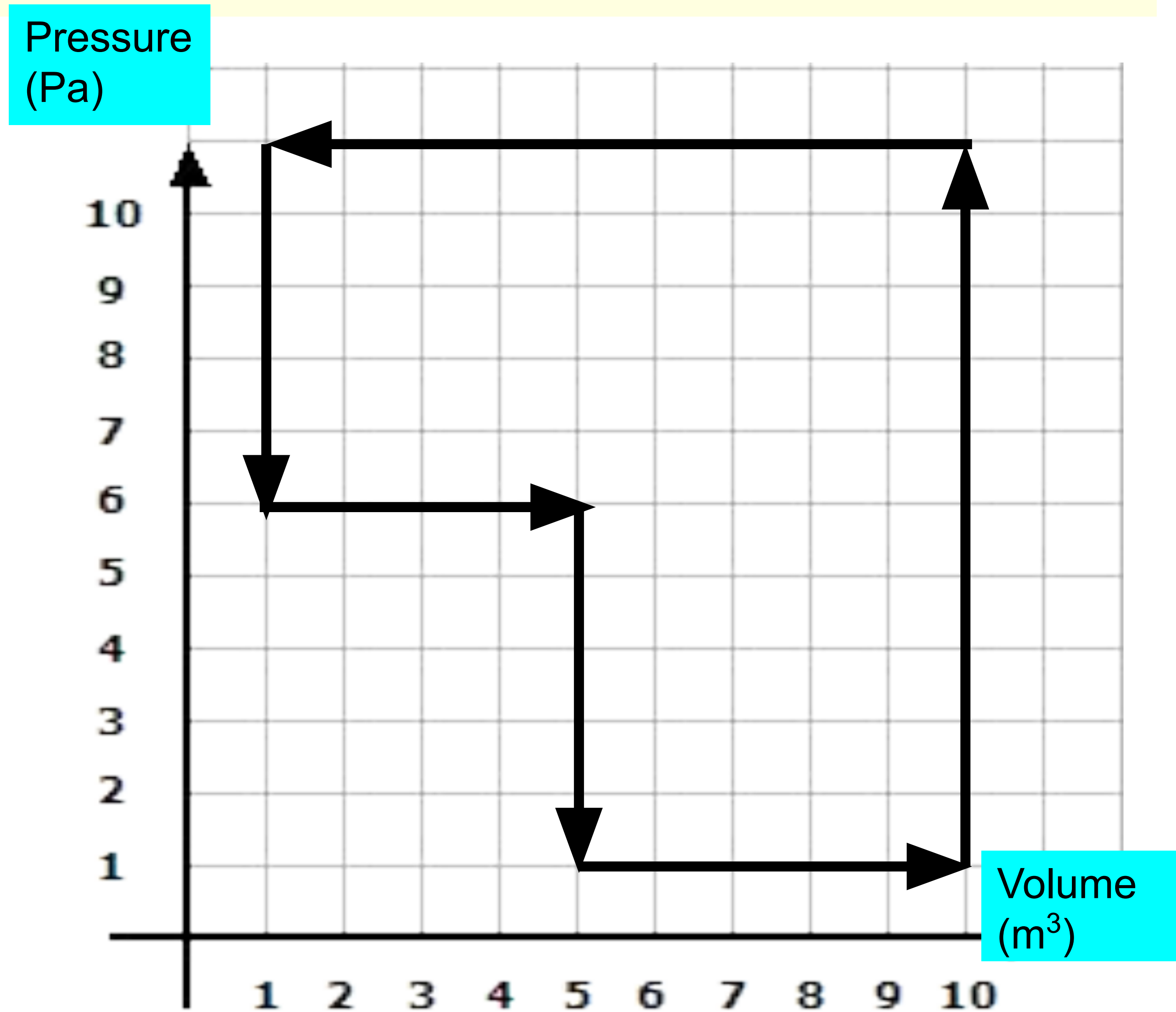
W_{total} over the PV cycle is:

A) 50 J
B) -50 J
C) 70 J
D) -70 J
E) NOTA



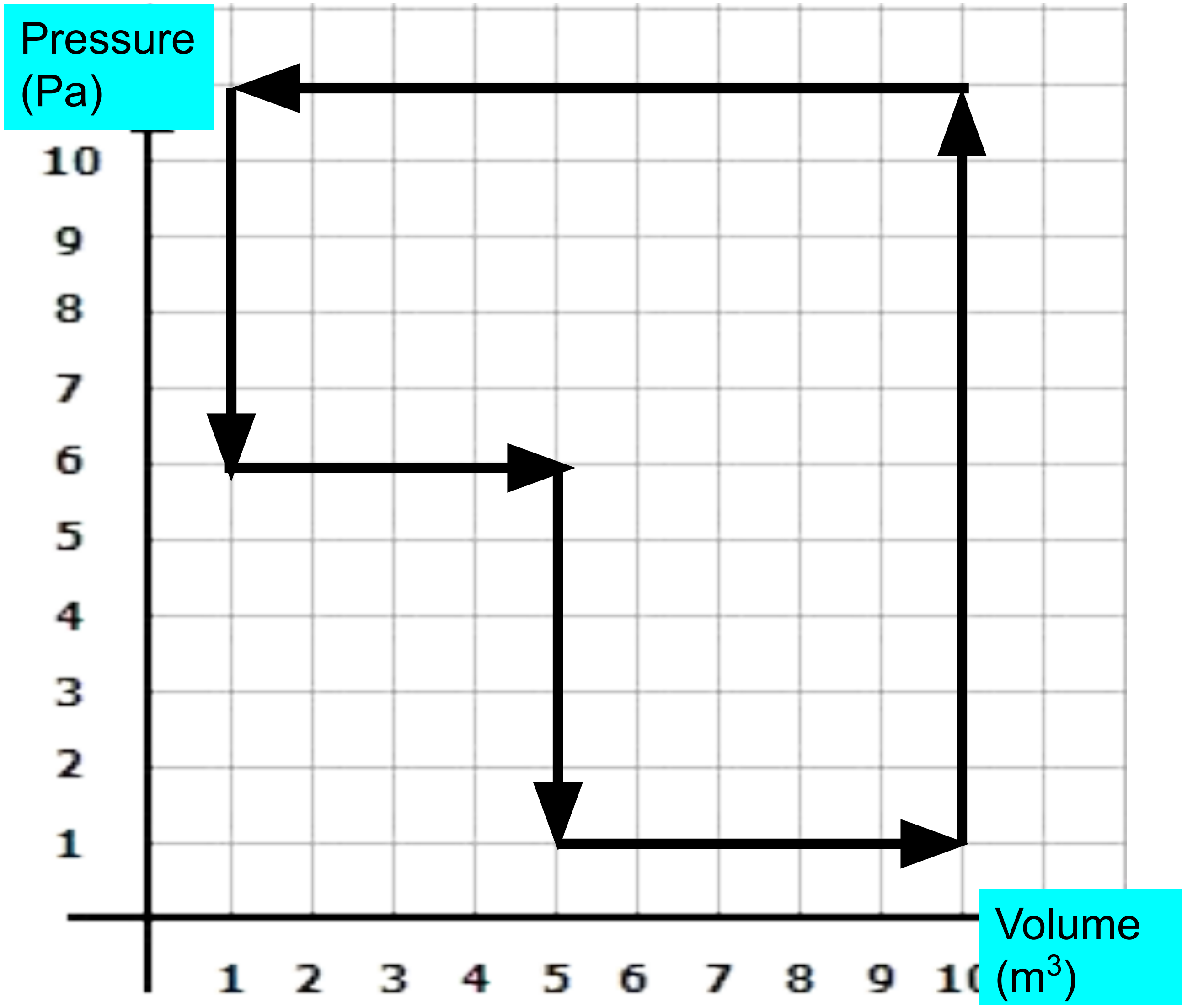
If there are 10^{22} particles in the system, the change in temperature from (10 m^3,11 Pa) → (1,11) is

A) 797 K
B) -797 K
C) 717 K
D) -717 K
E) NOTA



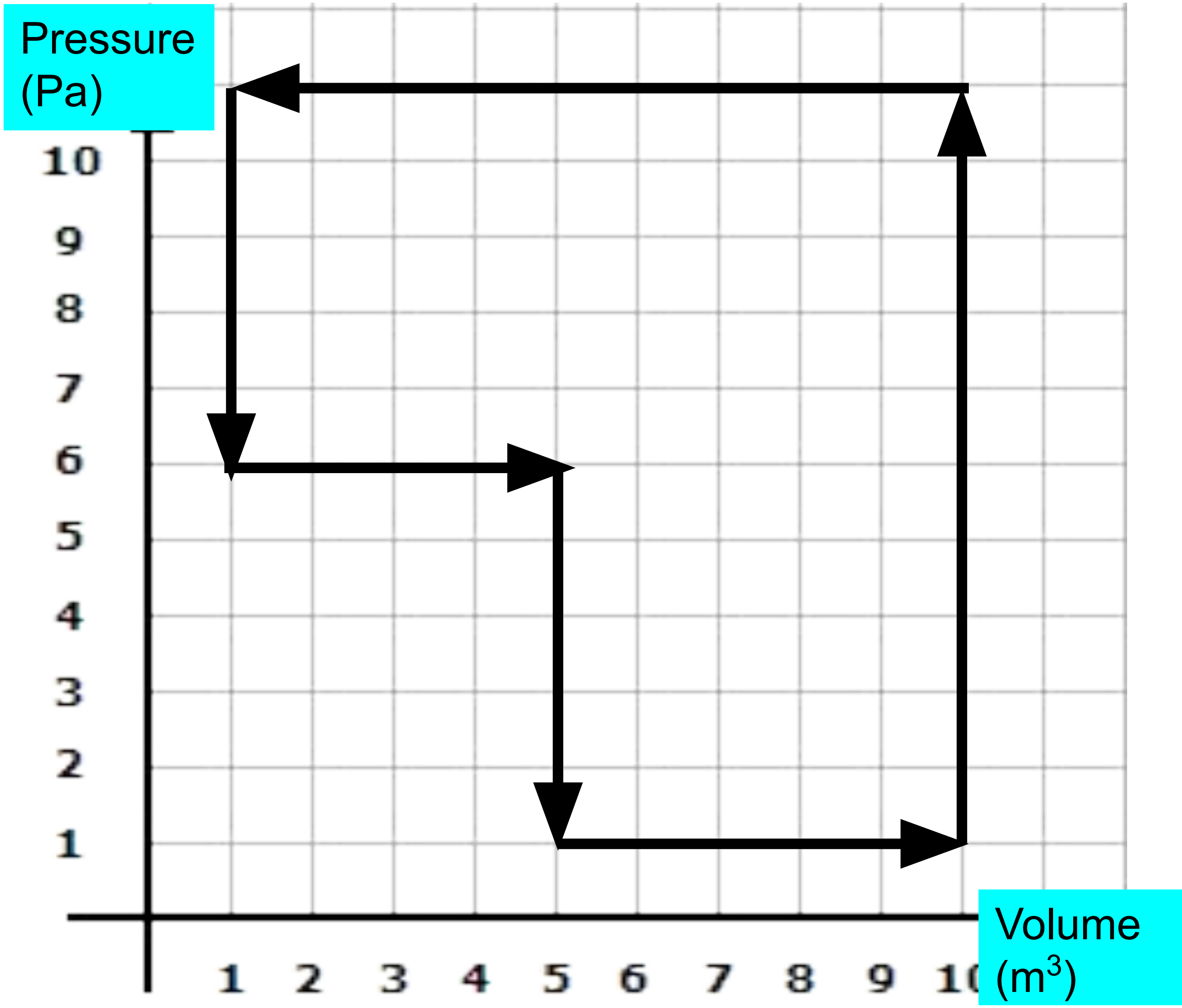
If there are 10^{22} particles in the system, the change in internal energy from (10 m^3,11 Pa) → (1 m^3,11 Pa) is

A) 135 J
B) -135 J
C) 148.5 J
D) -148.5 J
E) NOTA

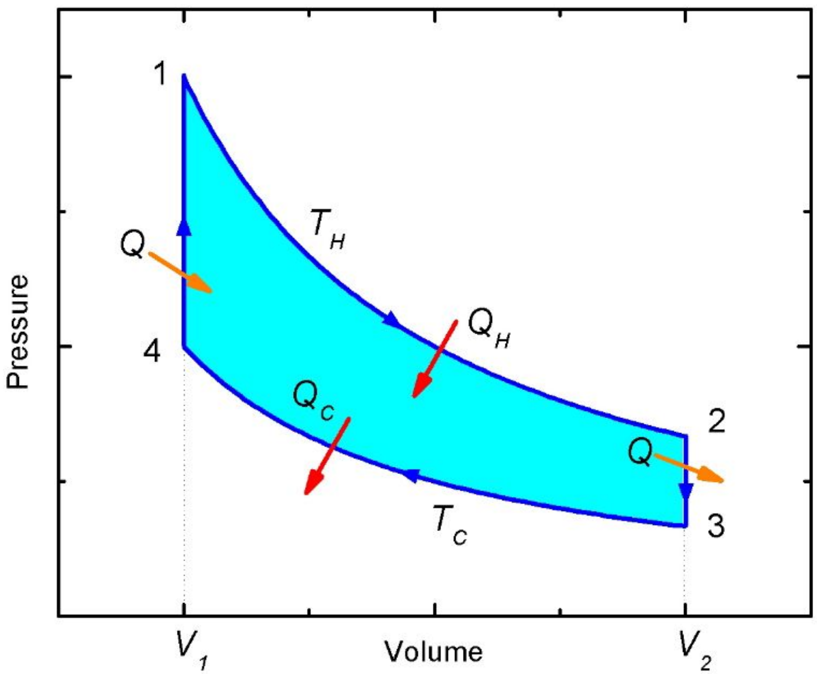


If there are 10^{22} particles in the gas, the heat added (Q_{input}) to the gas is (take ε=1 [true for 'reversible' process, so no change in entropy]):

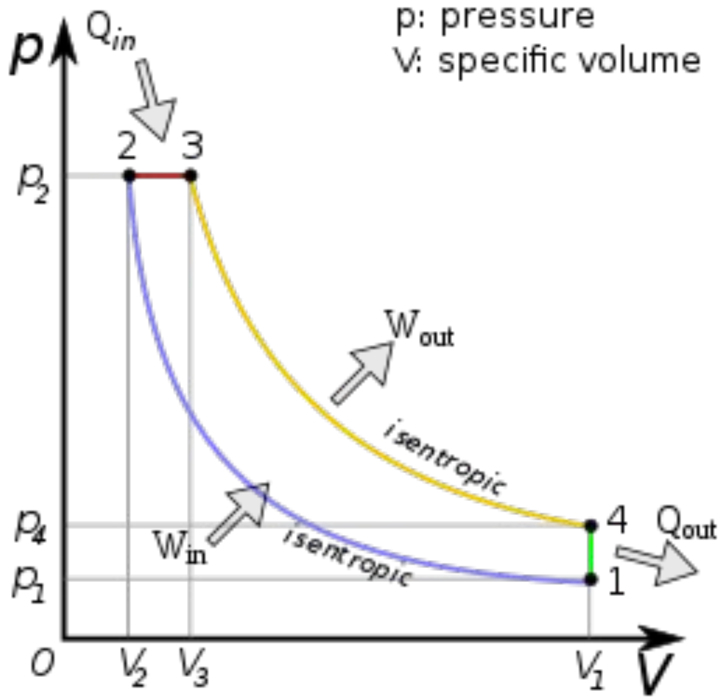
A) 247.5 J
B) -247.5 J
C) 218.5 J
D) -218.5 J
E) NOTA

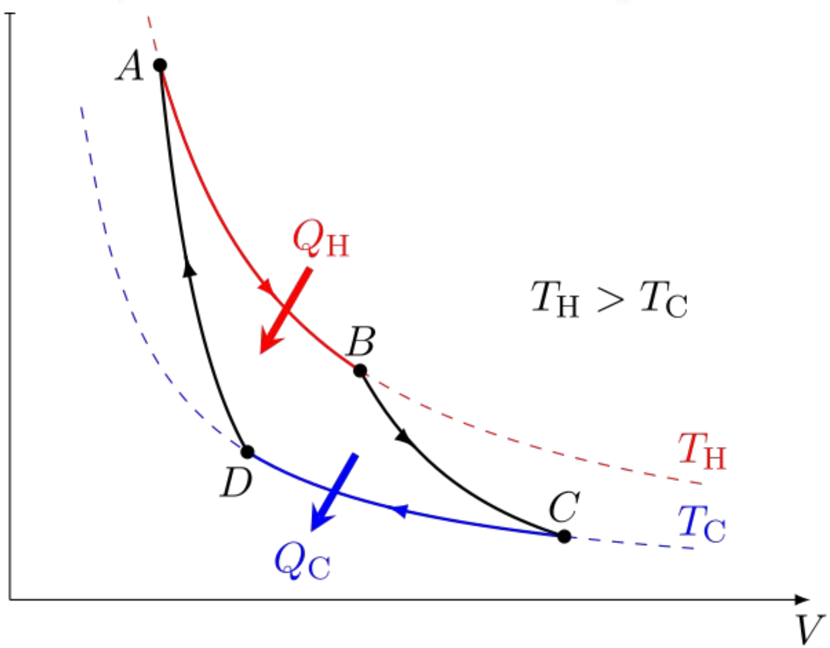


Stirling Cycle: Two isotherms connected by two constant volume processes



Diesel Cycle: Two adiabats connected by one constant volume and one constant pressure process



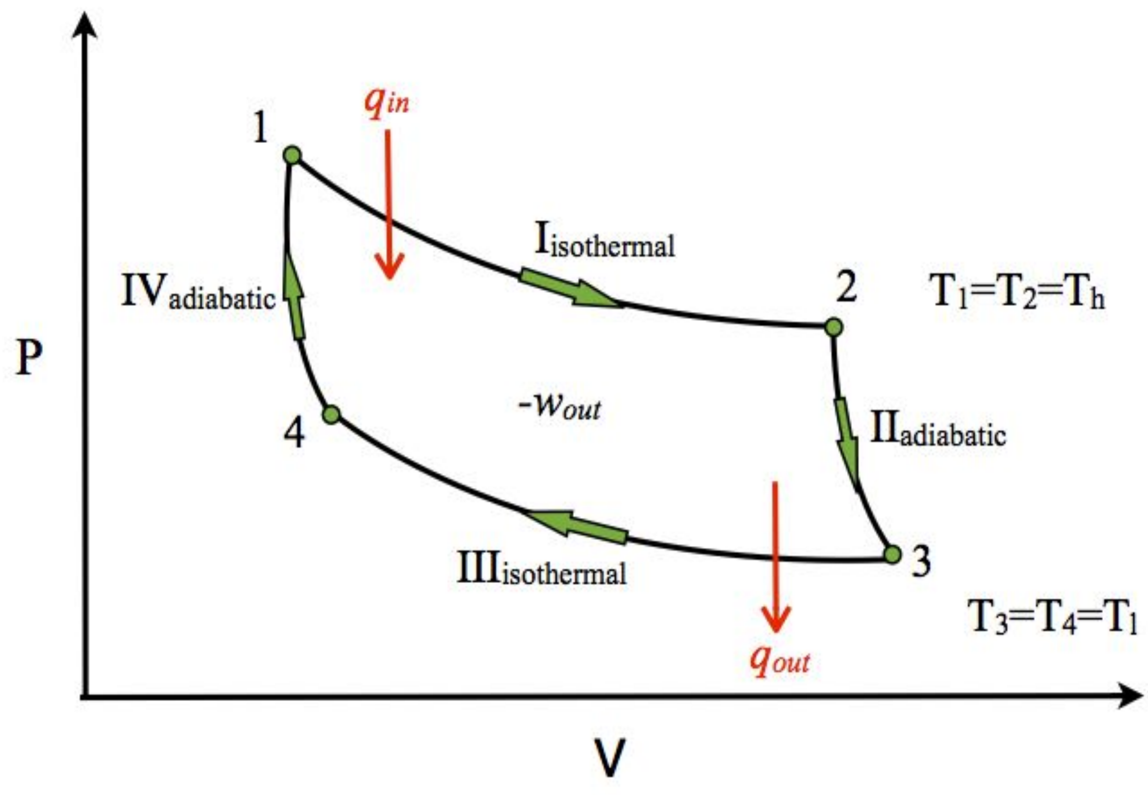


Carnot Cycle: Two isotherms connected by two adiabats

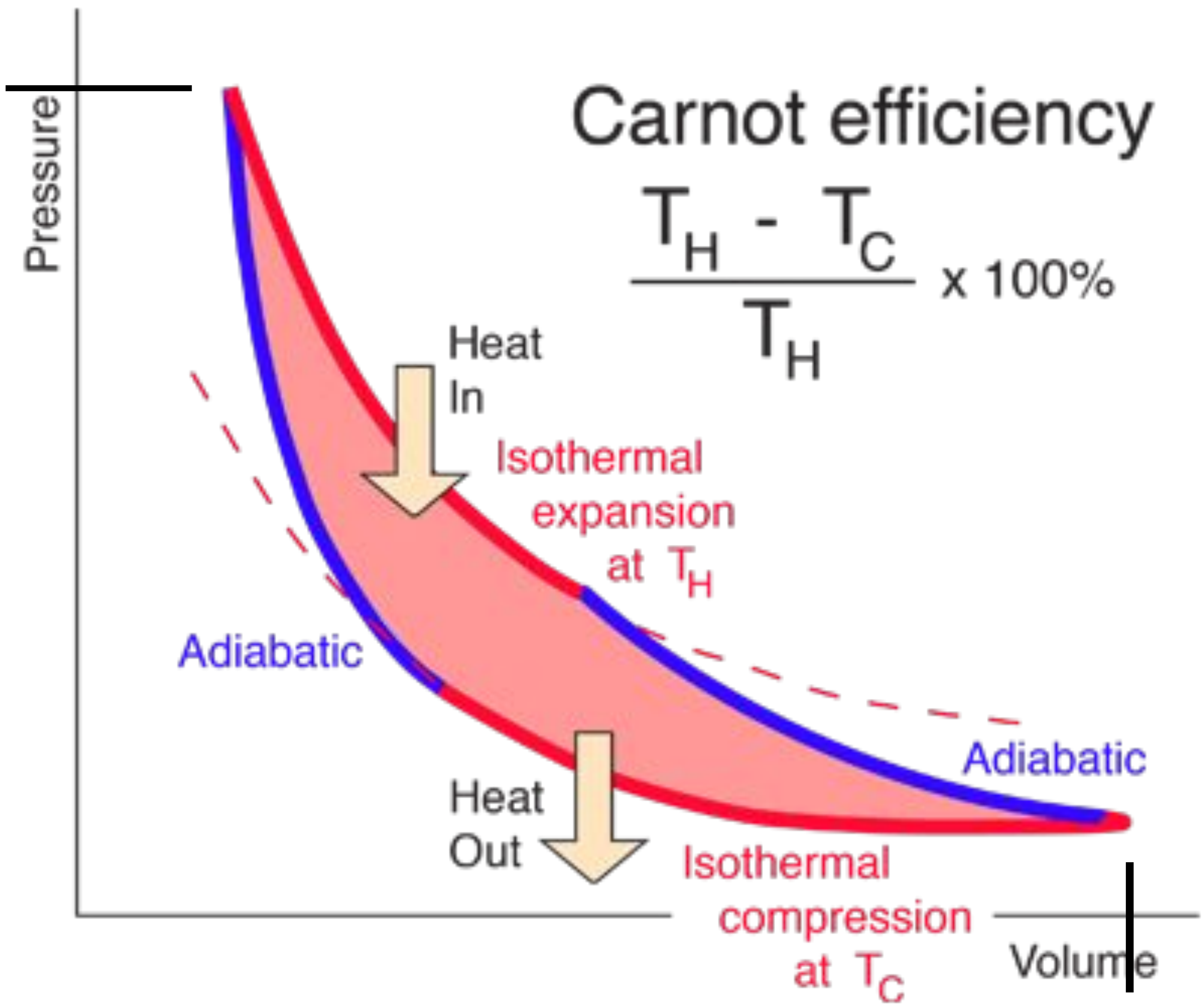
Always: ε=W/Q;
for Carnot,
ε=1-T(low)/T(high)

Given that P_1=10 Pa, and V_3=20 m^3, then ΔQ over a full cycle is about: (assume Fig. approximately to scale)

A) 10 J
B) 20 J
C) 80 J
D) 200 J
E) 300 J



For the Carnot cycle shown, with P_{max}=10 Pa and V_{max}=12 m^3, W_{done}~



A) +50 J

B) +20 J

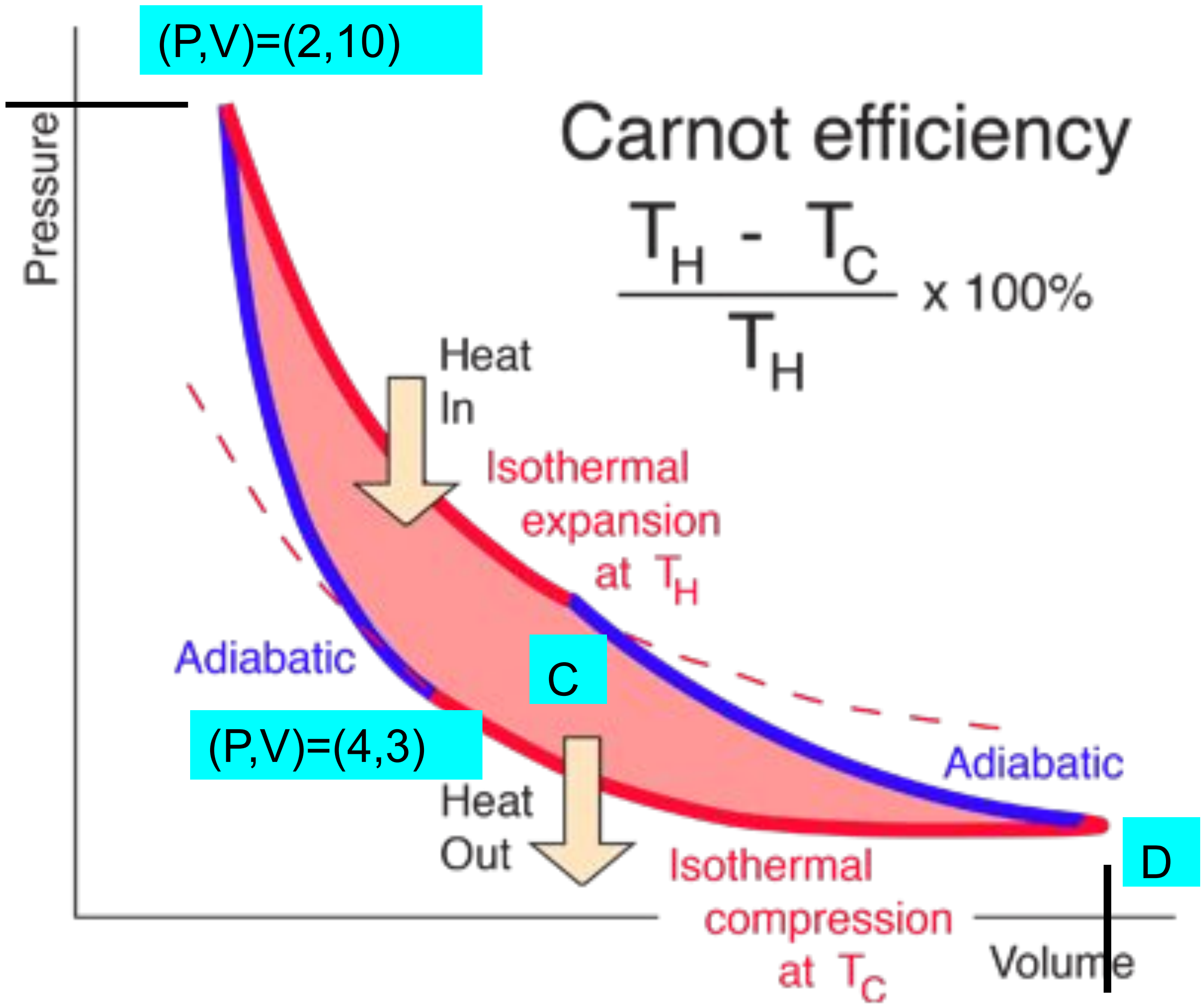
C) +80 J

D) +120 J

E) -120 J

Entropy change in top step=?

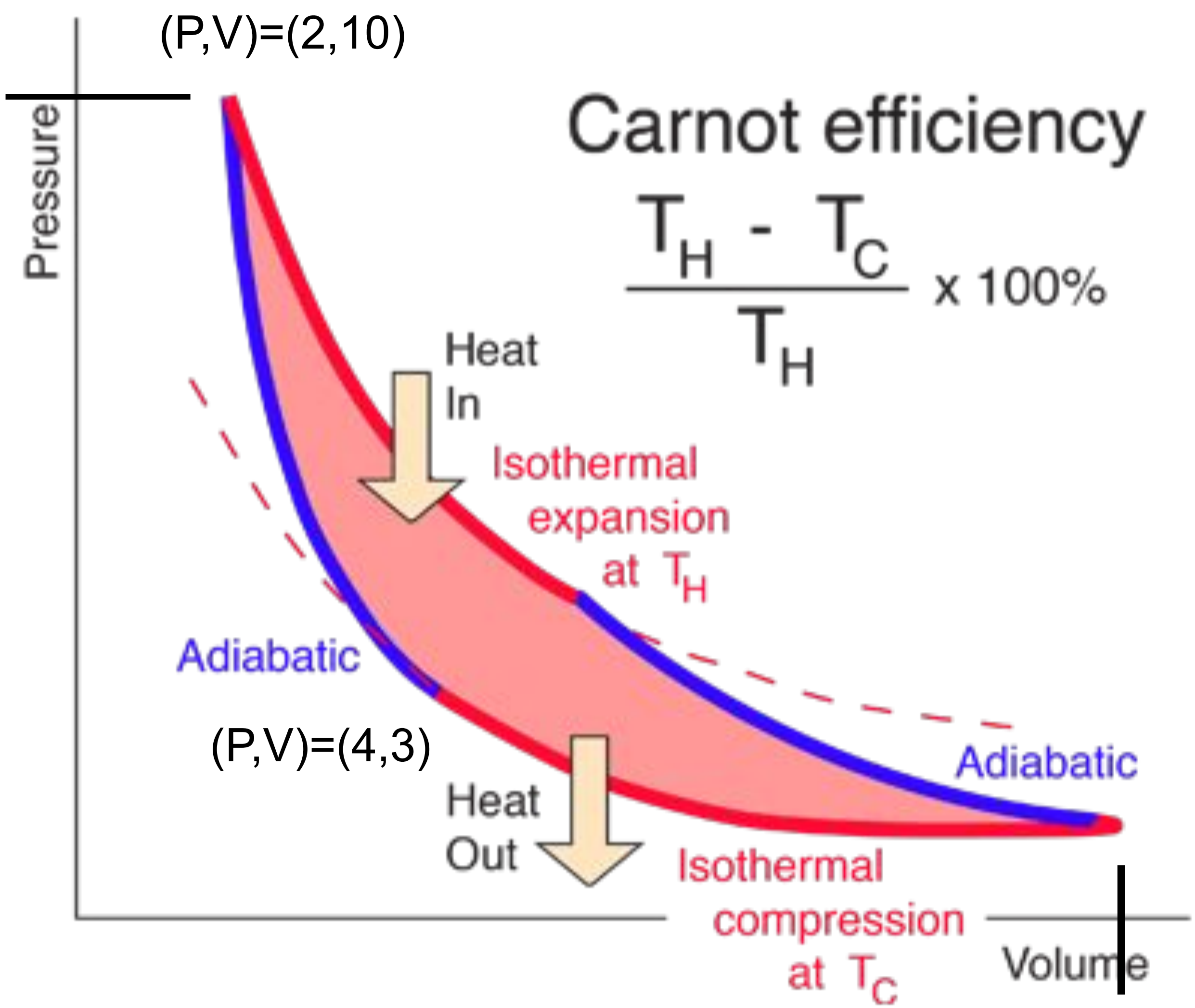
For the Carnot cycle shown, with $(P_A,V_A)=(2,10)$ and $(P_B,V_B)=(4,3)$, what are the pressures at points C and D if $V_C=5\ m^3$ and $V_D=12\ m^3$?



A) 5 Pa, 3 Pa
B) 6 Pa, 1 Pa
C) 5 Pa, 2 Pa
D) 4 Pa, 1 Pa
E) NOTA

Entropy change in top step=?

For the Carnot cycle shown, with P_{max}=10 Pa and V_{max}=10 m^3, Q_{added}~



A) +20 J
B) +190 J
C) +50 J
D) +270 J
E) W<0

Entropy change in top step=?

Which of the following would **definitely** improve the efficiency of the Carnot cycle shown?

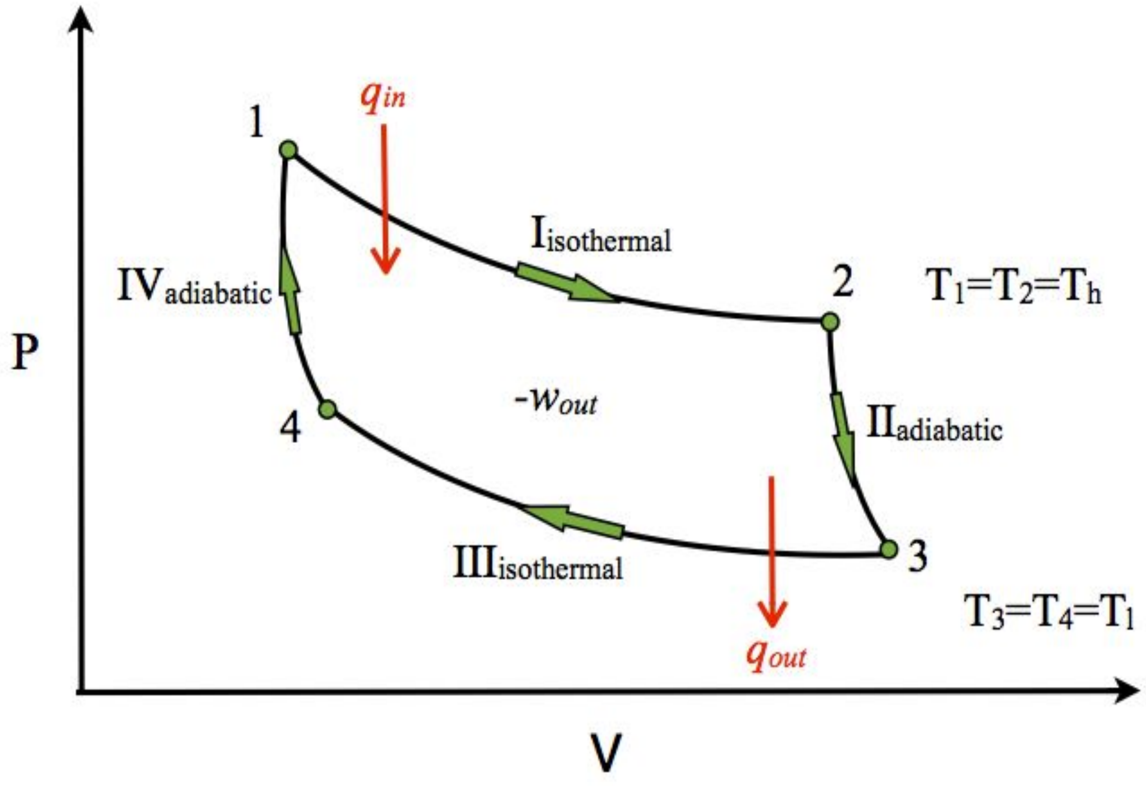
A) Changing $N_{particles}$ (but with the same PV-curve)

B) “Compressing” the graph vertically

C) “Stretching” the graph vertically

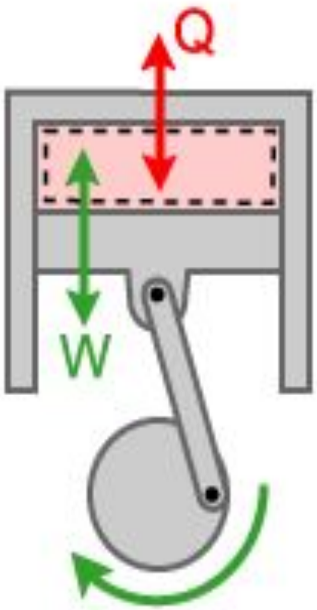
D) “Stretching” the graph horizontally

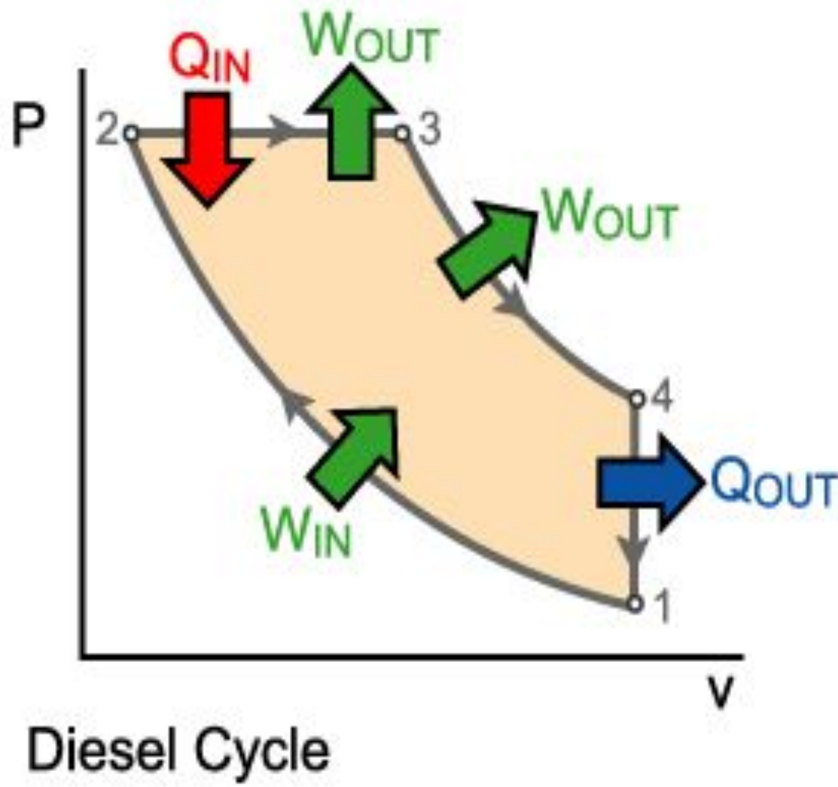
E) At least two of the above



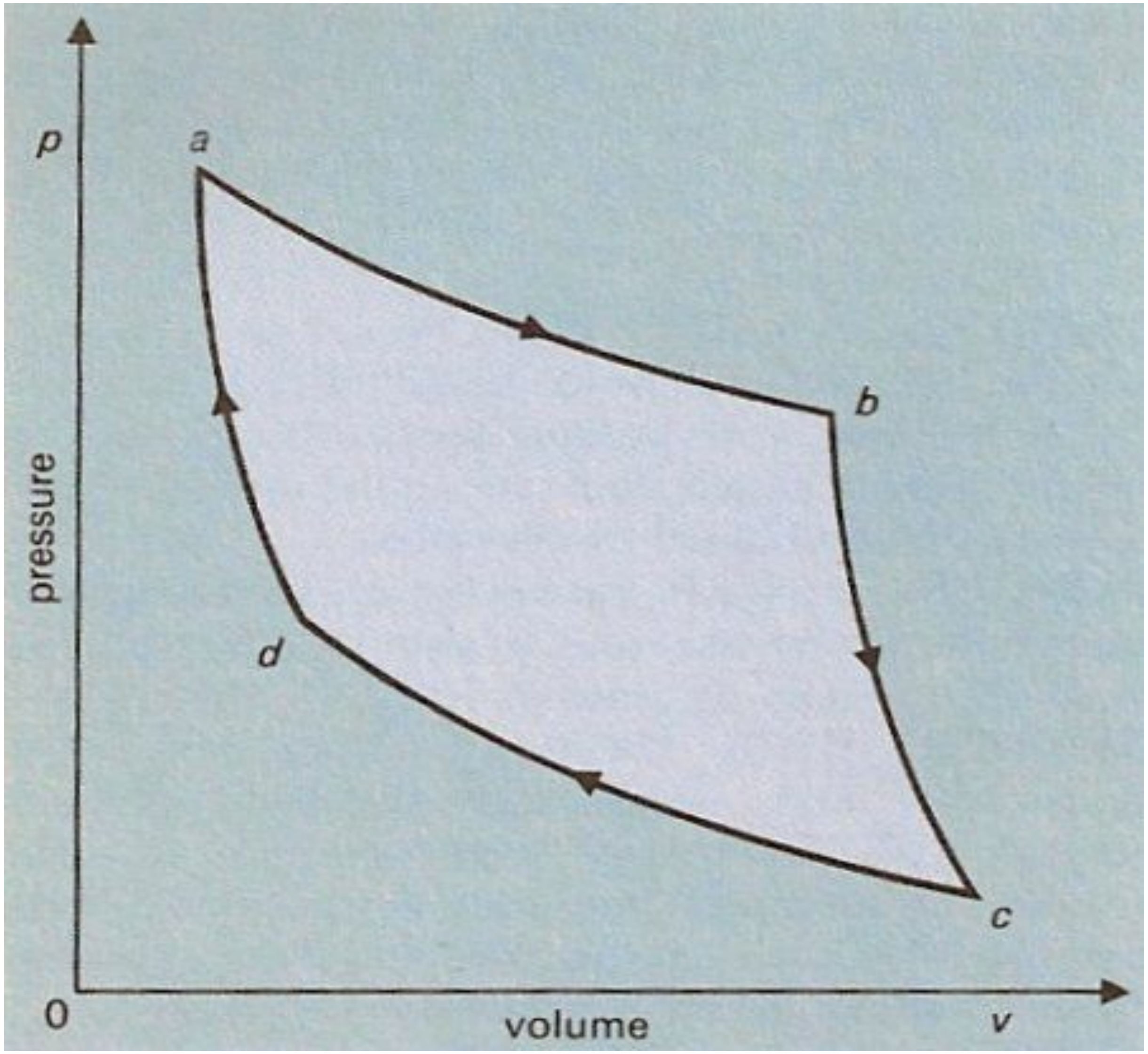
Verbrennungsmotoren Idealisiertes p(v) und T(s) Diagramm des Dieselmotors (Saug- und Ausstosshub blau dargestellt). Which is true of step 1→2?

A) $Q_{IN}<0$; $\Delta U>0$; $W_{done}<0$
B) $Q_{IN}=0$; $\Delta U=0$; $W_{done}=0$
C) $Q_{IN}>0$; $\Delta U>0$; $W_{done}>0$
D) $Q_{IN}<0$; $\Delta U=0$; $W_{done}<0$
E) NOTA





Given: P_a=10 Pa, V_a=1 m^3, what is ΔQ for the entire cycle?

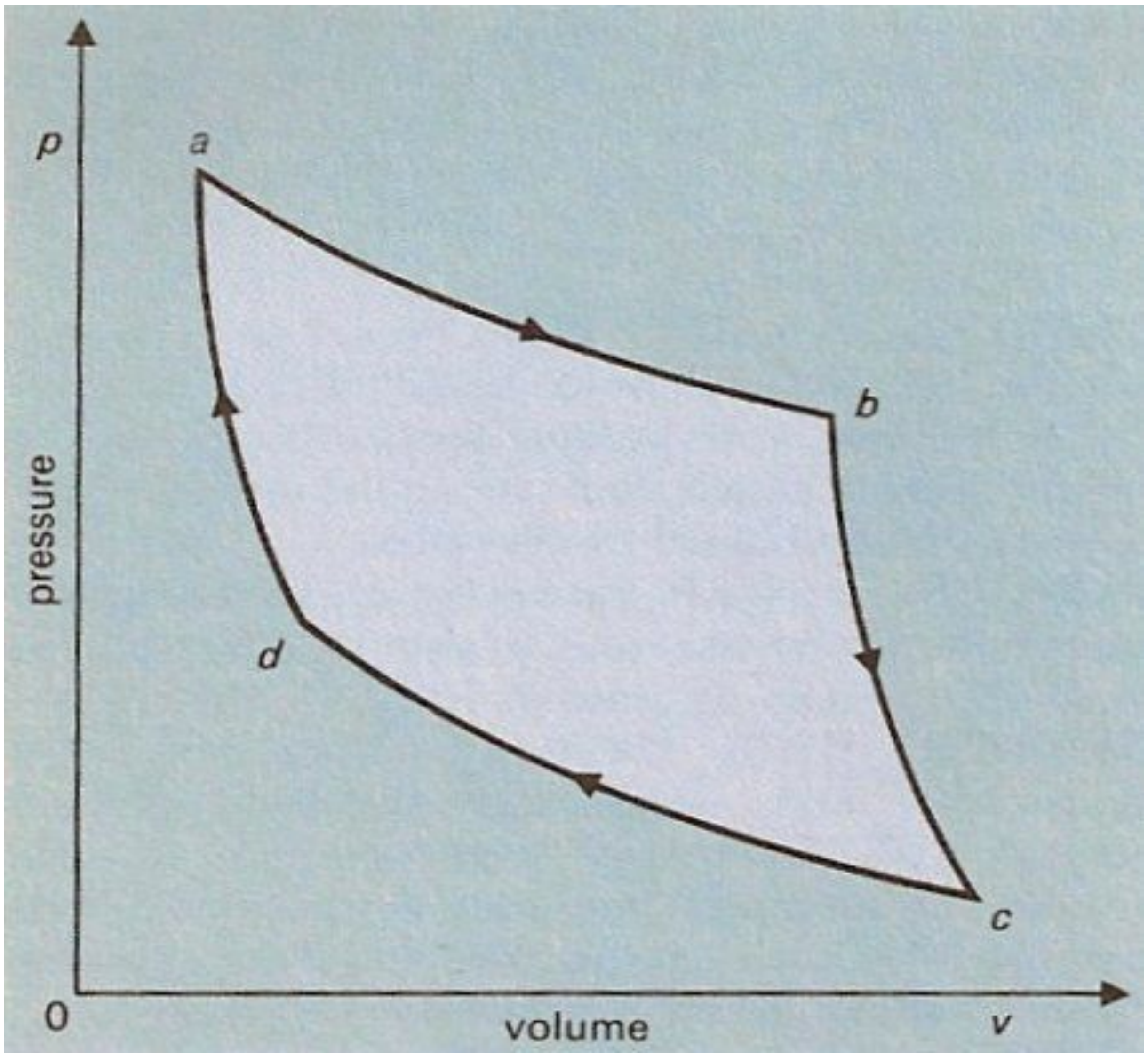


A) 5 J

B) 50 J

C) 500

Given: 32 g of O_2 with P_a=10 Pa, V_a=1 m^3, what is ΔS for c→d?



A) -0.5 J/K

B) -2 J/K

C) -10 J/K

D) -20 J/K

E) NOTA

Which statement is true?

A) The work done by a gas is independent of the path taken from the initial (pressure,volume) to the final (pressure, volume) and only depends on the initial and final points.

B) The change in internal energy…

C) The heat added…

D) Two of the above are true

E) NOTA

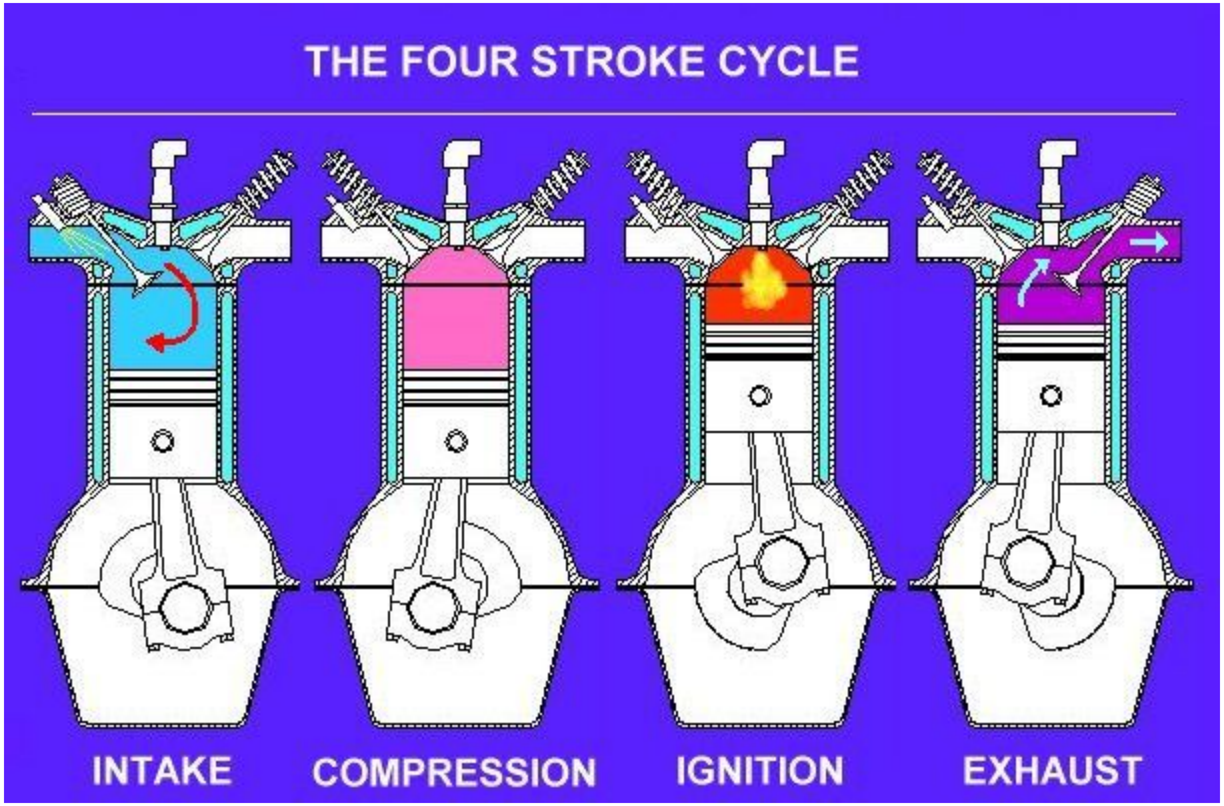
Which statement is true?

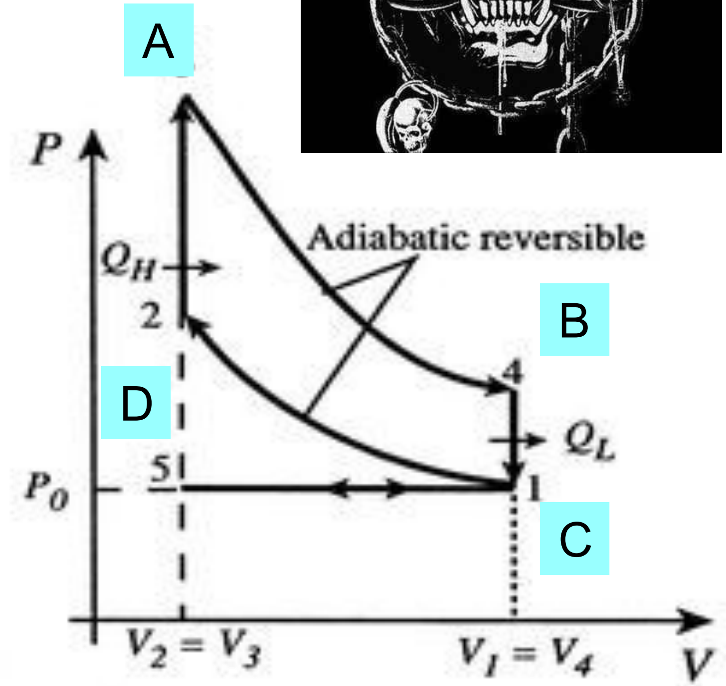
A) If a gas does positive work, the change in internal energy also has to be positive

B) If a gas does positive work, the change in internal energy has to be negative

C) If a gas does positive work, the change in internal energy can be positive or negative

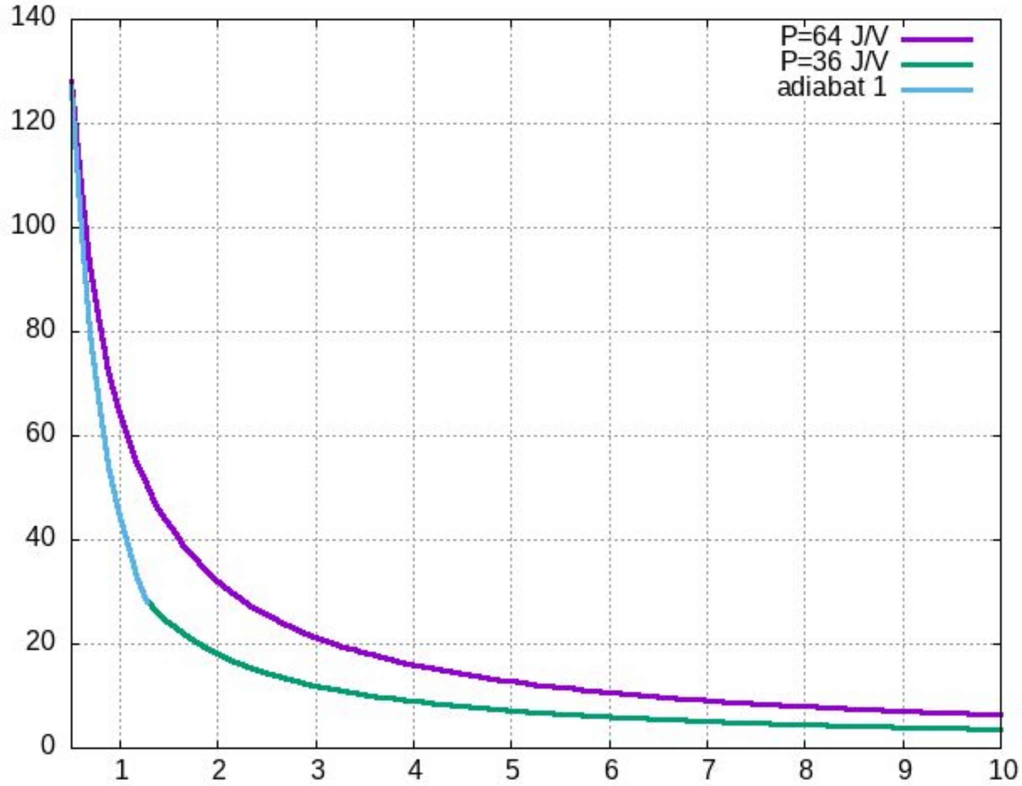
The 4-stroke ICE Otto cycle (includes ignition step, and compression ratio=V_4/V_2)





Constructing a Carnot cycle ("curved parallelogram"):

1. Define the high-temperature isotherm - starting at some initial P_iV_i, trace a curve P(V)=nKT/V, or P=constant/V. It will be easiest if you start with P=V, but this is not necessary. In the diagram that follows, I used P=64 J/V
2. Now define the low-temperature isotherm, which should have just a different constant (I used P=36 J/V.
3. Now we draw an adiabatic curve that connects the two. Since $\Delta Q=\Delta U+W_{done}$, $\Delta U=-W_{done}$, so in this example ΔU=36 J-64 J=-28 J. The work done is therefore +28 J (Aside, why isn't $\Delta U=3/2W_{done}$? Difference b/w integrating and a straight line dependence.
   Assuming your graph paper is graduated, you know the 'size' of each box, and can estimate how the curve looks, depending on the size of each box.



Constructing Carnot Cycles

A) 1. Select upper left point P_1,V_1 , now draw isotherm to new point P_2,V_2 such that PV=constant, or $P \sim 1/V$

B) 2. Draw lower-temperature isotherm, again, with $P \sim 1/V$

C) 3. Draw side legs by a) having $V_f > V_i$, but $(PV)_f < (PV)_i$ and, conversely, b) having $V_i > V_f$, but $(PV)_i < (PV)_f$

Typical numbers for a car engine

SUV: 3000 kg; v=20 m/s (~60 mph), so W(tot)=600,000 J

Suppose engine revving at 8000 rpm=>100 strokes per second (each stroke=1 full cycle through PV-diagram), so to achieve 60 mph in 4 seconds requires that each stroke deliver 1500 J. For an 8-cylinder car (8 cylinders per stroke, one spark plug per cylinder), this requires 200 J per stroke per cylinder.

Assume each cylinder has volume 5 cm x 5 cm x 5 cm, and expands by a factor of 10 during expansion, so $\Delta V \sim 1.25 \times 10^{-4}$ m^3, so pressure inside chamber given by $P\Delta V=200$, or $P=16 \times 10^5$ Pa, or 16 x P_{atm}.

Ch. 13 – Temperature, Kinetic Theory, Ideal Gas Law:

$PV=NkT$; $k=1.38 \times 10^{-23}$ J/K OR

$PV=nRT$; $R=8.31441$ J K^{-1} mol^{-1}

(R=0.082 atm*L/mole*K);

<KE>= $\frac{1}{2} mv^2 = 3/2\ kT = U$ ("Internal E) so:

$PV=NkT=N(2/3)(3/2kT)=N(2/3)(\frac{1}{2}mv_x^2 + \frac{1}{2}mv_y^2 + \frac{1}{2}mv_z^2)$

Aside: excludes rotational motion – for diatomic molecules, in principle, need to add $\frac{1}{2}I\omega^2$ as well as vibrational modes

A **12** m^3 volume contains $\mathbf{4x10^{23}}$ diatomic $\mathbf{O_2}$ molecules at a pressure **8000 Pa**. What is the rms linear velocity (in one-dimension) of each molecule?

A) 92 m/s

B) 112 m/s

C) 303 m/s

D) 2126 m/s

E) NOTA

A **12** m^3 volume contains **$4x10^{23}$** diatomic **O_2** molecules at a pressure **8000 Pa** What is the rms rotational velocity of each molecule (use the way oversimplified formula for separation distance: $r(m)=sqrt(Z)x10^{-10}$ m?

A) rad/s

A **12** m^3 volume contains **$4x10^{23}$** diatomic **O_2** molecules at a pressure **8000 Pa** What is the equivalent 'spring constant' of the diatomic bond, assuming that the molecules 'stretch' the bond distance by 50%

A) N/m

800 Helium gas atoms are in a box with volume 1 m^3 and temperature 27° C. The average velocity of each Helium gas ($m=6.65 \times 10^{-27}$ kg) atom is

A) 300 m/s

B) 1115 m/s

C) 644 m/s

D) 221 m/s

E) NOTA

800 Helium gas atoms are in a box with volume 1 m^3 and temperature 27° C. The gas atoms now push on the sides of the box at constant pressure, so that the final volume is 3 m^3. The work done by the gas is:

A) 6.62×10^{-18} J

B) 0.000411 J

C) 2 J

D) 20 J

E) NOTA

In the previous problem, which of the following must be true (consider how/why the gas expands)?

A) The temperature of the gas has increased
B) The temperature of the gas is constant
C) The temperature of the gas has decreased

100 J of heat is applied to two 1 m^3 containers (initially) of gas with the same number of particles; container A has a flange so that its volume is variable. After 10 seconds, which temperature is higher?

A) $T_A = T_B$

B) $T_A > T_B$

C) $T_B > T_A$

100 J of heat is applied to two 1 m^3 containers (fixed volume) of identical gas particles; container A has twice the number of particles as container B. After 10 seconds, which temperature is higher?

A) $T_A = T_B$

B) $T_A > T_B$

C) $T_B > T_A$

100 J of heat is applied to two 1 m^3 (fixed volume) containers having the same number of gas particles; container A has Helium while container B has Argon. After 10 seconds, which temperature is higher?

A) $T_A = T_B$

B) $T_A > T_B$

C) $T_B > T_A$

An ideal gas has its total number of particles doubled, while its volume also doubles. Assuming temperature remains constant, the gas pressure

A) Doubles

B) Quadruples

C) Is unchanged

D) Is halved

E) Is reduced by a factor of 4

The ratio of velocities of O_2 at 1200° K vs. H_2 at 300° K, is (i.e., v_O/v_H)

A) ½

B) ¼

C) 1

D) 4

E) NOTA

The ratio of the temperature of 32 grams of O_2 to 32 grams of O at the same Pressure and Volume is:

A) 1

B) ½

C) 2

D) 8

E) NOTA

A *rigid* box contains 1000 O atoms. With time, oxygen atoms combine to form O_2. As this happens, which statement is true (N.B: 1) $\Delta Q=0$; 2) neglect the exothermal heat released in $2O \rightarrow O_2$)?

A) P increases, average gas velocity increases

B) P decreases, average gas velocity is constant

C) P decreases, average gas velocity decreases

D) P remains constant, average gas velocity constant

E) NOTA

A box containing hydrogen gas (H_2) is mixed with a box containing O_2. If the average velocities of the H and O molecules are the same before mixing, then, after mixing:

A) H_2 speeds up; O_2 slows down

B) H_2 slows down; O_2 speeds up

C) Both slow down

D) Both speed up

E) Velocities are unchanged

A cubic liter of 1000 O_2 molecules is confined to one side of a movable partition; a cubic liter of 1000 H_2 molecules are on the other side. What is the ratio of temperatures in the two partitions such that the partition remains stationary?

A) 16

B) 4

C) 1

D) ¼

E) NOTA

Dalton's Law of Partial Pressures – the pressure of a mixture is the same as sum of the pressure of the species added separately.

Problem: 20 g of Ne at temp T are mixed with 4 g of He at temp T. After mixing, how does He temp change?

1) Temperature argument – temperatures should remain constant. Note that partial pressures remain same after mixing.

2) (Bogus) Momentum argument: Ne has higher average momentum, so Neon should transfer its momentum to Helium and get cooler? A: For ideal gases with elastic collisions which conserve KE, the momenta do not equilibriate! (see http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/kineticmoleculartheory.htm)
see: http://phet.colorado.edu/en/simulation/gas-properties. Alternately, thermal equilibrium is defined by KE of all species being equal, NOT momenta being =

Ch. 16: Waves and Oscillations:

$x(t)=A\sin(\omega t)$ – true for both "transverse" as well as "longitudinal" waves

General wave concepts: Superposition, Interference, Energy and Power in waves, Beats, Doppler Shifts

A 4 kg mass is on a frictionless floor, attached to a spring with spring constant 128 N/m, and initially extended to x=+2 m. The velocity at x=0 is:

A) 9.8 m/s

B) 8.03 m/s

C) 16.14 m/s

D) 11.3 m/s

E) NOTA

A 4 kg mass is on a frictionless floor, attached to a spring with spring constant 128 N/m, and initially extended a distance 2 m. At the point x=-1 m, the velocity is:

A) 9.8 m/s

B) 8.04 m/s

C) 16.04 m/s

D) 11.3 m/s

E) NOTA

A 4 kg mass is on a frictionless floor, attached to a spring with spring constant 128 N/m, and initially extended a distance 2 m. The time required to make 1.5 oscillations is:

A) 2.9 seconds

B) 0.9 seconds

C) 1.35 seconds

D) 1.66 seconds

E) NOTA

A 4 kg mass is on a rough floor (μ_K=0.102), attached to a spring with spring constant 128 N/m, and initially extended a distance 2 m. The total distance the mass travels before coming to a stop is:

A) 4 meters

B) 8 meters

C) 32 meters

D) 64 meters

E) NOTA

A 2 kg mass is on a spring with spring constant 8 N/m. Determine the time that is required for the mass to make 4 complete oscillations

A) 4.4 seconds

B) 2.89 s

C) 12.56 s

D) 32.33 s

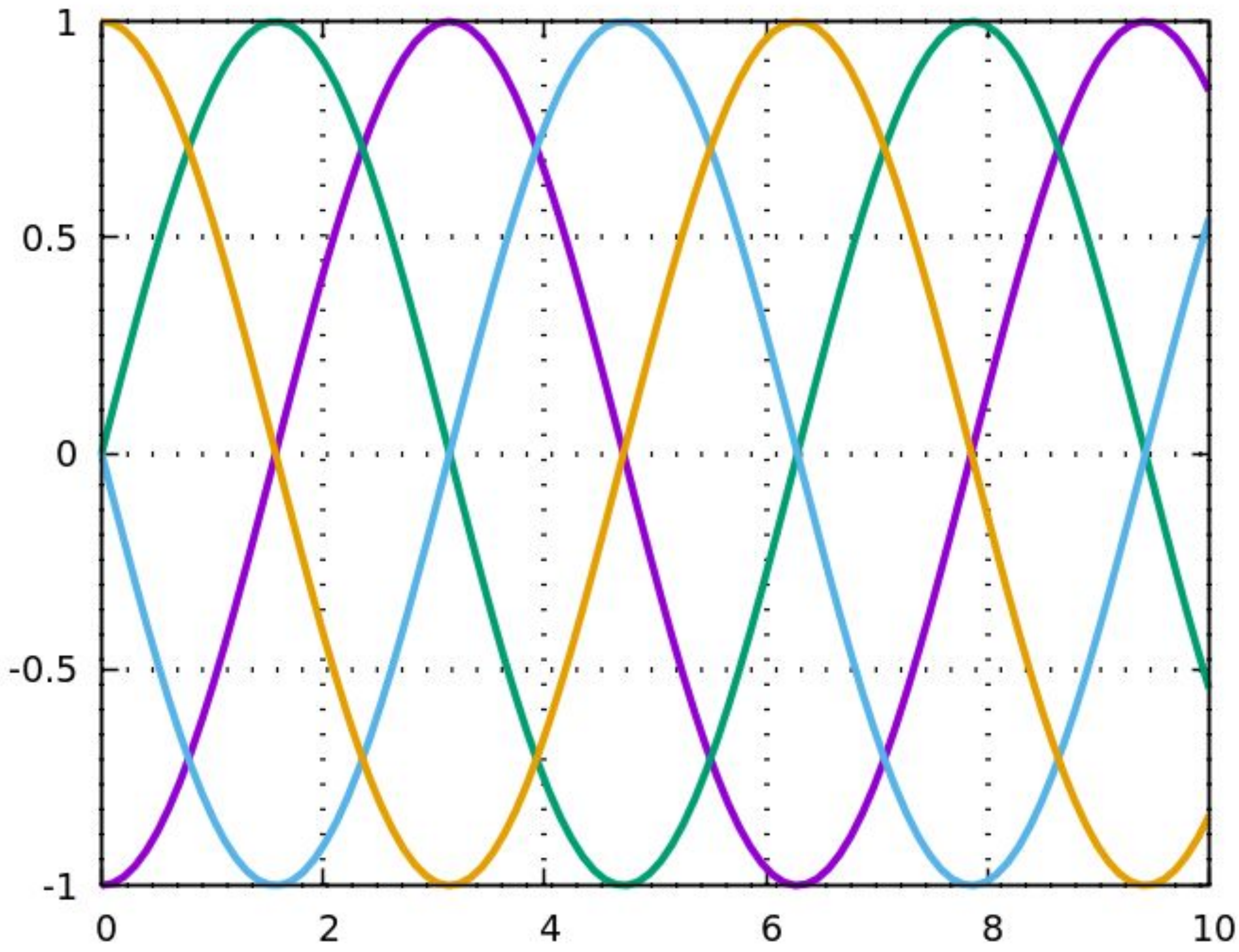
E) NOTA

A mass on a spring, on a frictionless table, is pulled in the -x-direction and then released. Which statement is true of the displacement (recall that $F=-kx$)

A) x(t) is always anti-parallel F(t)
B) x(t) is always parallel to F(t)
C) x(t) is parallel to F(t) over the 1st and 3rd quarter-cycles only
D) NOTA

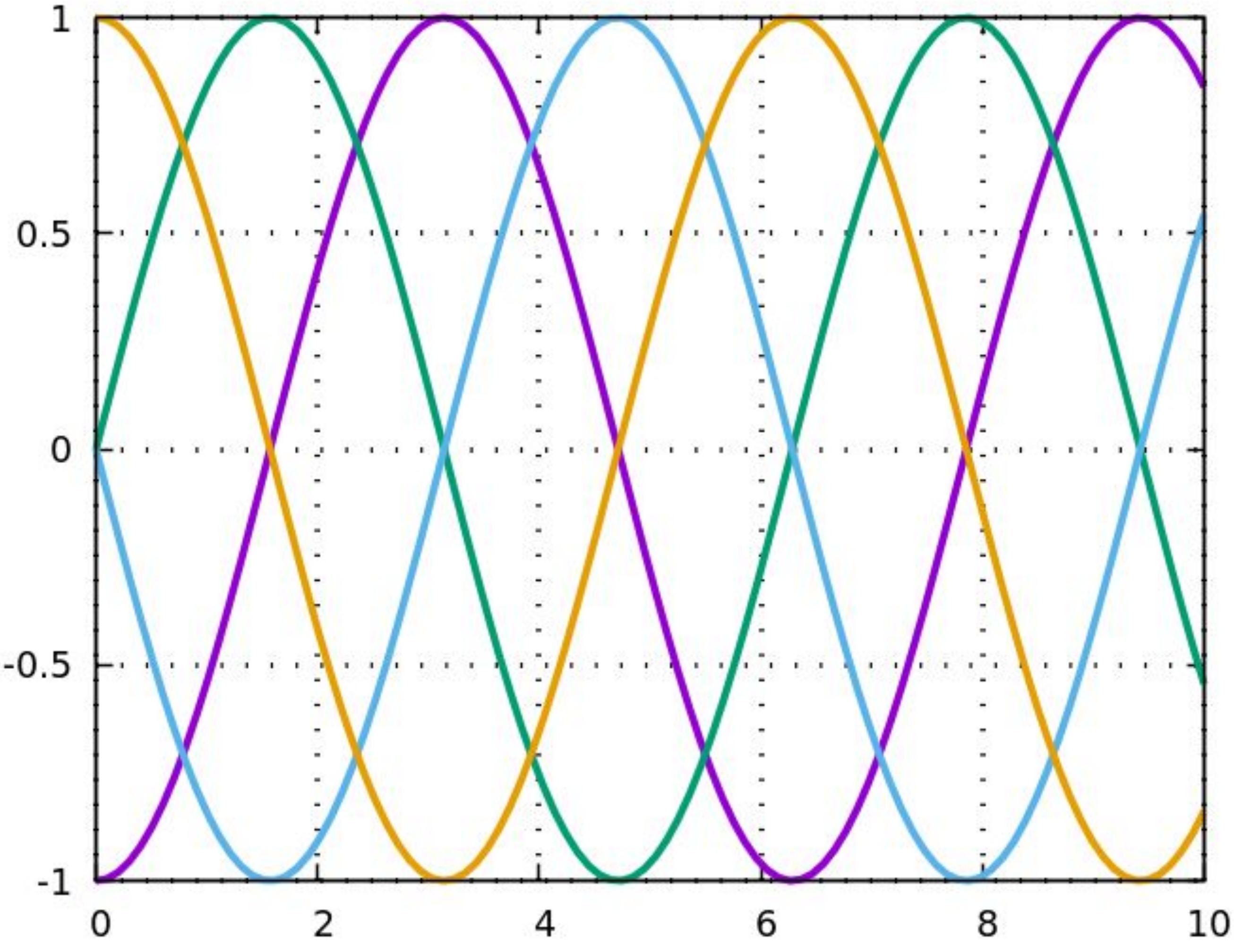
A mass on a spring, on a frictionless table, is pulled in the -x-direction and then released (similar to the Hooke's Law lab). Given that, which curves correctly represent the shapes of x(t) and $F_{net}(t)$ (which is also the shape of a(t), since a(t)=F(t)/m)?

A) cyan, purple
B) green, cyan
C) purple, purple
D) purple, orange
E) NOTA



A mass on a spring, on a frictionless table, is pulled 1m in the -x-direction and then released (similar to the Hooke's Law lab). Given that, which curve correctly represents v(t)?

A) green
B) cyan
C) purple
D) orange
E) NOTA



A 2 kg mass is pulled back, on a frictionless table, a distance 80 cm on a spring having spring constant 4 N/m. The velocity of the spring as it passes through x=0 m is:

A) 1.2 m/s

B) 1.44 m/s

C) 0.98 m/s

D) 1.13 m/s

E) NOTA

A 2 kg mass is pulled back, on a frictionless table, a distance 80 cm on a spring having spring constant 4 N/m. The velocity of the spring as it passes through x=-40 cm is:

A) 1.2 m/s

B) 1.44 m/s

C) 0.98 m/s

D) 1.13 m/s

E) NOTA

Over one full cycle, which statement is true?

A) The total work done by all forces acting on the mass is >0

B) $W_{tot}<0$

C) $W_{tot}=0$

Over the first quarter-cycle, which statement is true?

A) The total work done by all forces acting on the mass is >0

B) $W_{tot}<0$

C) $W_{tot}=0$

A mass oscillates on a spring on a rough surface. As it moves through several cycles, which is true regarding the work done by the spring W_S, and friction W_F?

A) $W_S>0$ over the 1st and 2nd quarter-cycles

B) $W_F<0$ over all quarter-cycles

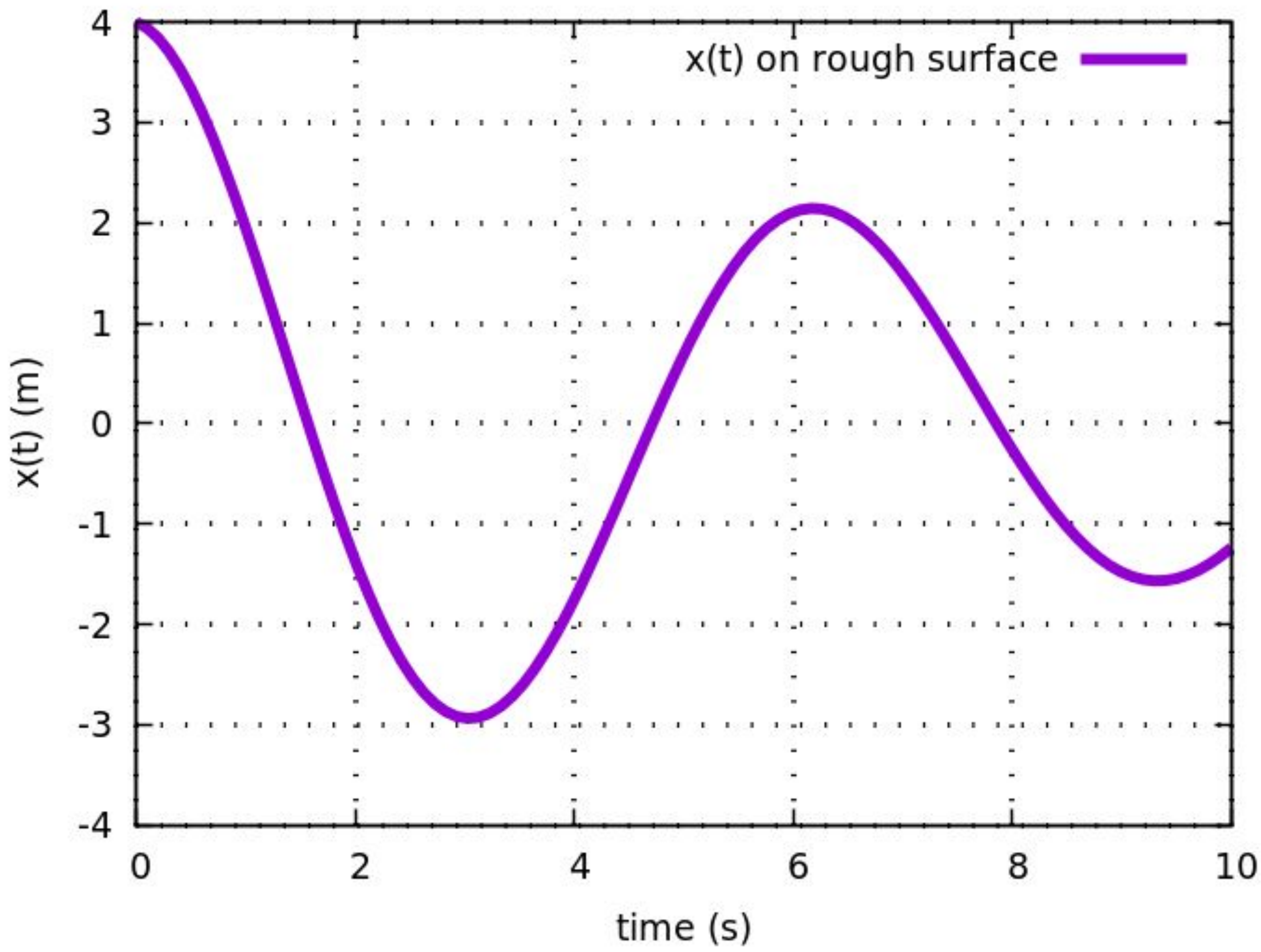
C) $W_S<0$ over the 4th and 2nd quarter-cycles

D) Two of the above are true

E) NOTA

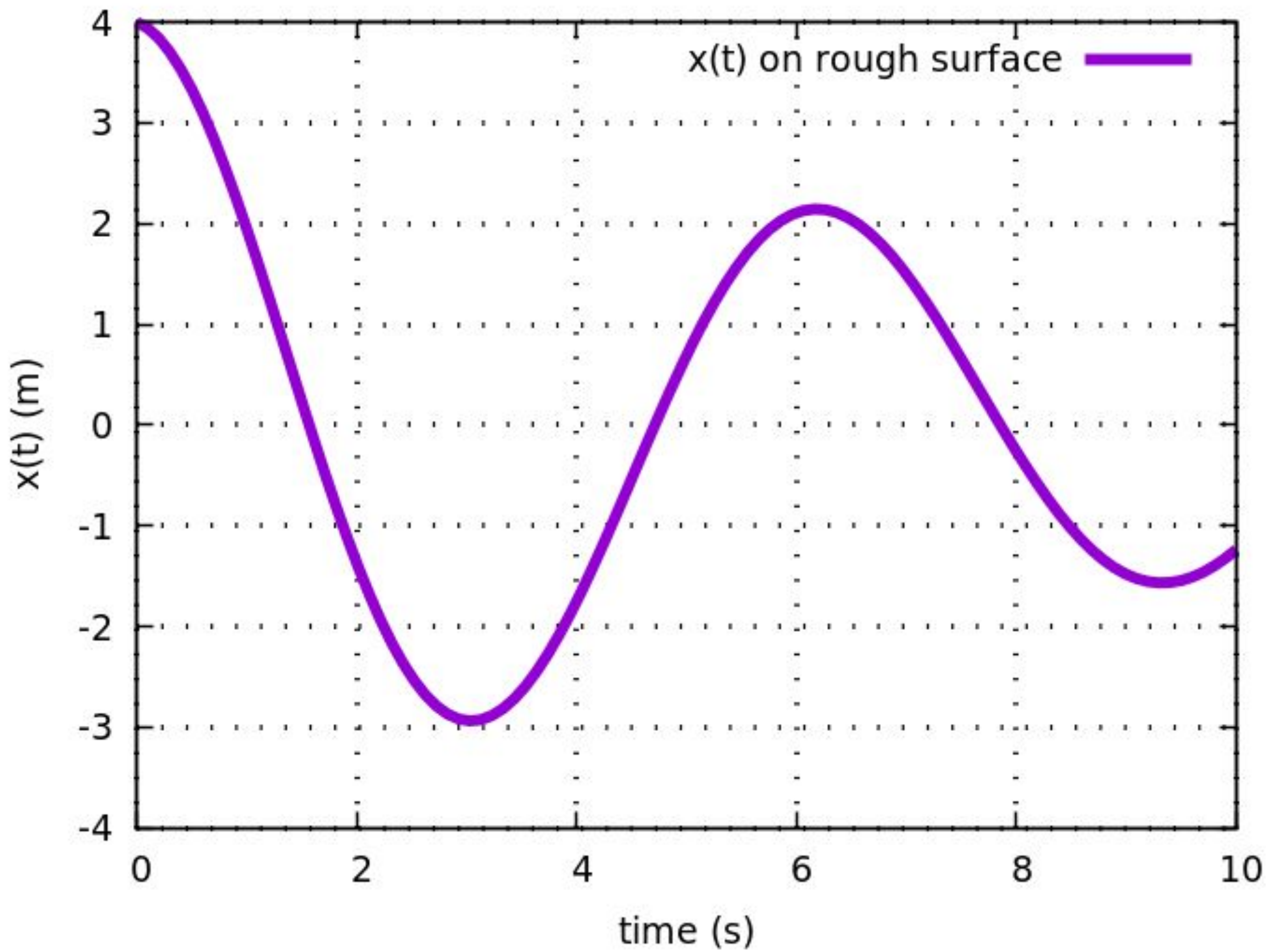
A mass on a rough surface is extended on a spring with k=2 N/m. From the graph, the work done by friction, over the first half-cycle is about:

A) -7 J
B) -3.5 J
C) -16 J
D) need to know mass
E) NOTA



A mass is put on a rough surface and extended on a spring with spring constant 2 N/m. Given x(t) below, the coefficient of kinetic friction is:

A) 0.0255
B) 0.1787
C) 0.3831
D) need to know mass
E) NOTA



A mass is given an impulse at t=0, which drives it in the -x direction. If the mass reaches its maximum compression after ½ s, what is the angular frequency of oscillation?

A) ω=2 rad/s

B) ω=4π rad/s

C) ω=π rad/s

D) ω=4 rad/s

E) NOTA

A wave having f=4/s and λ=2 m starts at x=0 at t=0 and travels in the +x-direction. The time at which the crest passes x=4 m is:

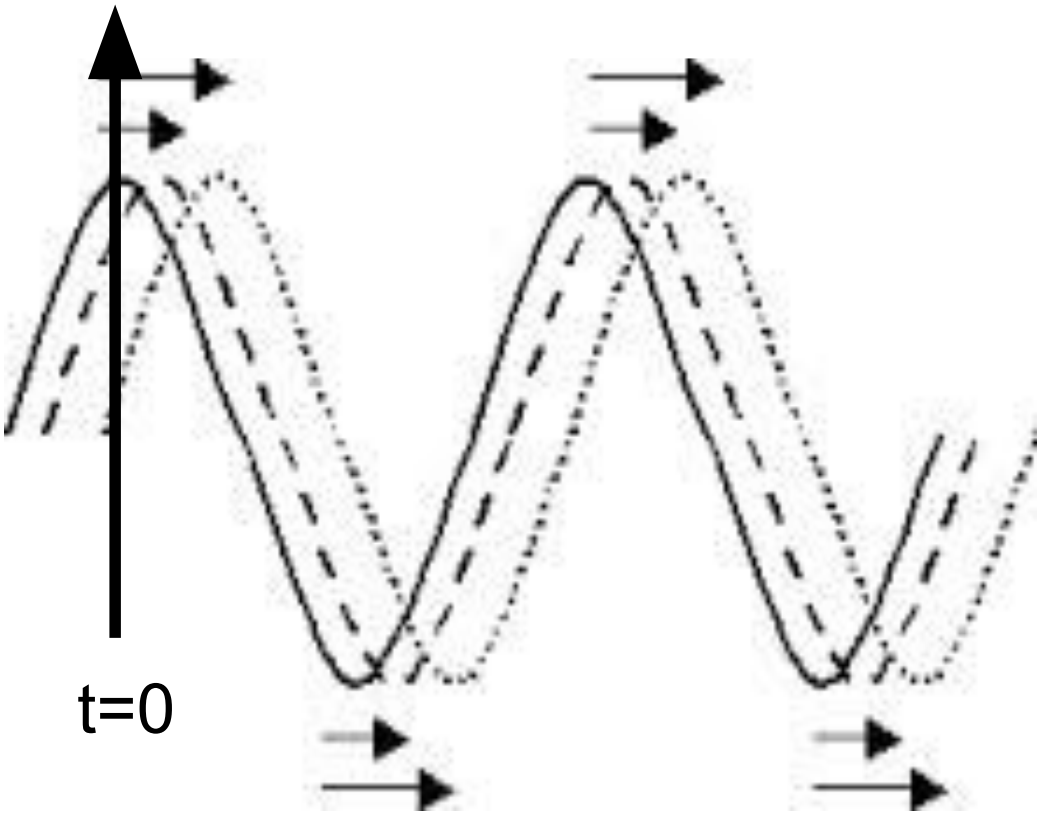
A) 1 s

B) 2 s

C) 4 s

D) 0.5 s

E) NOTA

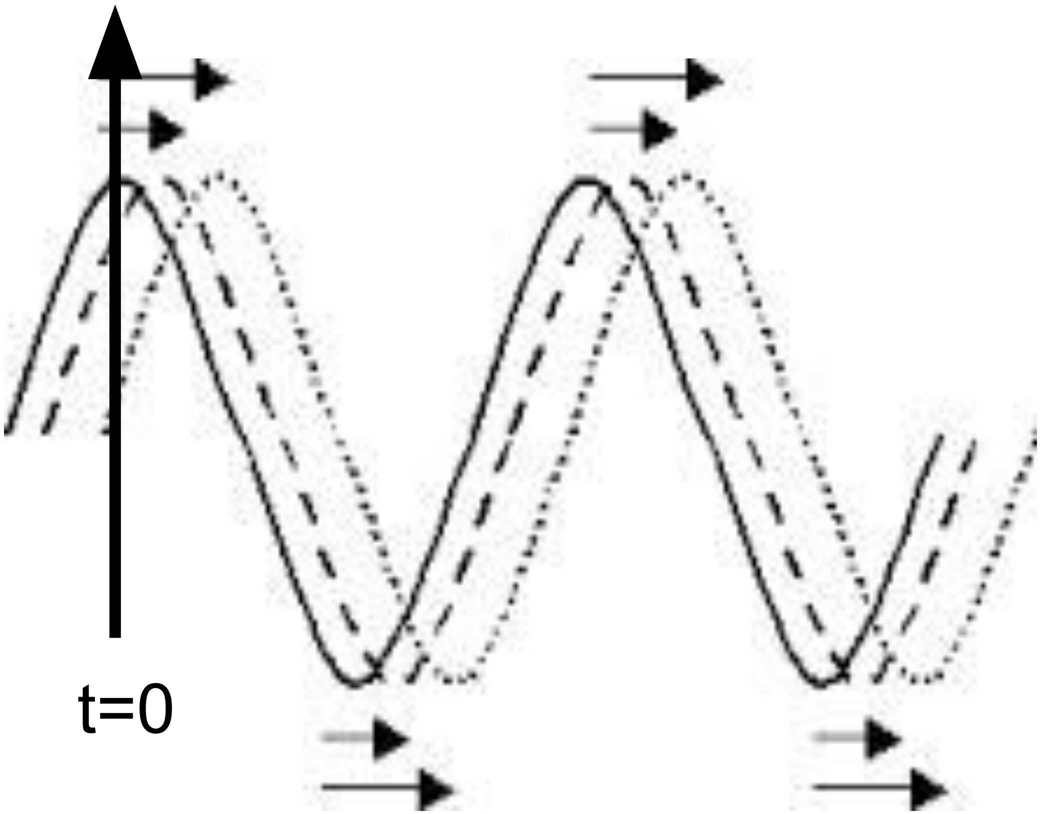


A wave having f=4/s and λ=2 m starts at x=0 at t=0 and travels in the +x-direction. Increasing the frequency would:

A) Reduce the time for the wave to reach x=4 m

B) Increase the time to reach x=4

C) Leave the time unaffected



Given two waves:

a) $y_1(t)=3m\cos(\pi(x-5t/4))$

b) $y_2(t)=2m\cos(\pi(x-3t/4))$. At x=6m, t=4s, what is the intensity of the 2 interfering waves, relative to the peak intensity of wave 2 only?

A) 0

B) 1

C) 4

D) 6.25

E) NOTA

Given two waves:

a) $y_1(t)=3m \sin(\pi(2x-t))$

b) $y_2(t)=2m \sin(\pi(4x-t)$. At x=50 cm, t=0.5s, what is the intensity of the 2 interfering waves, relative to the peak intensity of wave 2 only?

A) 0.25

B) 1

C) 4

D) 6.25

E) NOTA

Wave 1 has v=4 m/s, A=1 m and lambda=6 m./Wave 2 has v=2 m/s, A=2 m and lambda=4 m.
1) Assuming the two waves start at crests, how far have the two waves advanced at the time t=3 seconds?
Soln: Wave 1: v*t=(4 m/s)*3 seconds=12 m; wave 2: 2*3=6 m
2) At the point x=6 m, determine the relative ratio of intensities of Wave 1 only:Wave 2 only:Wave 1 interfering with wave 2
Soln: Wave 1 is at a crest, while wave 2 is at a trough. Relative intensities are: 1*1:2:2:(1-2)*(1-2) = 1:4:1
3) At the first point where the amplitude of wave 1 is at a trough, wave 2 has amplitude which is: a) >0 b) <0 c)=0?
Soln: This is x=3 m, so wave 2 has zero amplitude.

Repeat this exercise for the first harmonic of these 'fundamentals' (in this case, lambda1=3 m, so wave 1 has propagated through two full waves, while wave 2 (lambda2=2 m) has propagated through 3 full waves. Now both are at crests and the ratios are 1:4:9

A 2 kg mass, on a spring with spring constant k=40 N/m is pulled back a distance 4 m on a smooth surface.
a) The best guess for the average force exerted by the spring on the mass would be: i) 0 N, ii) 20 N, iii) 80 N, iv) 160 N (Answer=iii, since the Force=k*x and it varies between a maximum magnitude of 160 N and minimum of 0 N)
b) using your answer to a), what is the approximate period of the mass? Answer: over 1/4-cycle, 4m=0.5*at^2; average a=80N/4kg=20. Solve for t=0.63 seconds, so total period=2.32 s.
b) using the answer to a), what is the amount of work done by the spring over the first 1/4 cycle? A: 80N*4=+320 J
c) what is the amount of work done by the spring over the second 1/4 cycle (-320 J, since spring acts to decelerate)
d) the work done by the spring over one full cycle is: i) 640 N, ii) 1280 N, iii) 2560 N, iv) 10240 N, v) 0 N (total d=0)
e) What is the total "angular" displacement of the mass after it's moved a distance of 6 m? A: total cycle=16 m displacement, so here we have (6m/16m)*2pi radians.

Waves on a string or in a pipe- note that this is a resonance effect; constructive interference between forward-moving and backwards-moving waves

Given that f_0 for a 0.6 m low-E string on a guitar=82 Hz, which of the following statements is true for the second harmonic?

A) $f_2 < 82$ Hz; $\lambda_2 = \lambda_0$; $v_2 > v_0$

B) $f_2 = 82$ Hz; $\lambda_2 > \lambda_0$; $v_2 = v_0$

C) $f_2 > 82$ Hz; $\lambda_2 = \lambda_0$; $v_2 < v_0$

D) $f_2 > 82$ Hz; $\lambda_2 < \lambda_0$; $v_2 = v_0$

E) NOTA

A 2kg mass hangs at the end of a 2 m long, 10 g Al “string”. The frequency of vibration of the fundamental is:

A) 15.6 Hz
B) 62.6 Hz
C) 94.5 Hz
D) 108.8 Hz
E) NOTA

The sketch below indicates the density of air for sound waves traveling through an open pipe. At the points A and B, air is most likely to move:

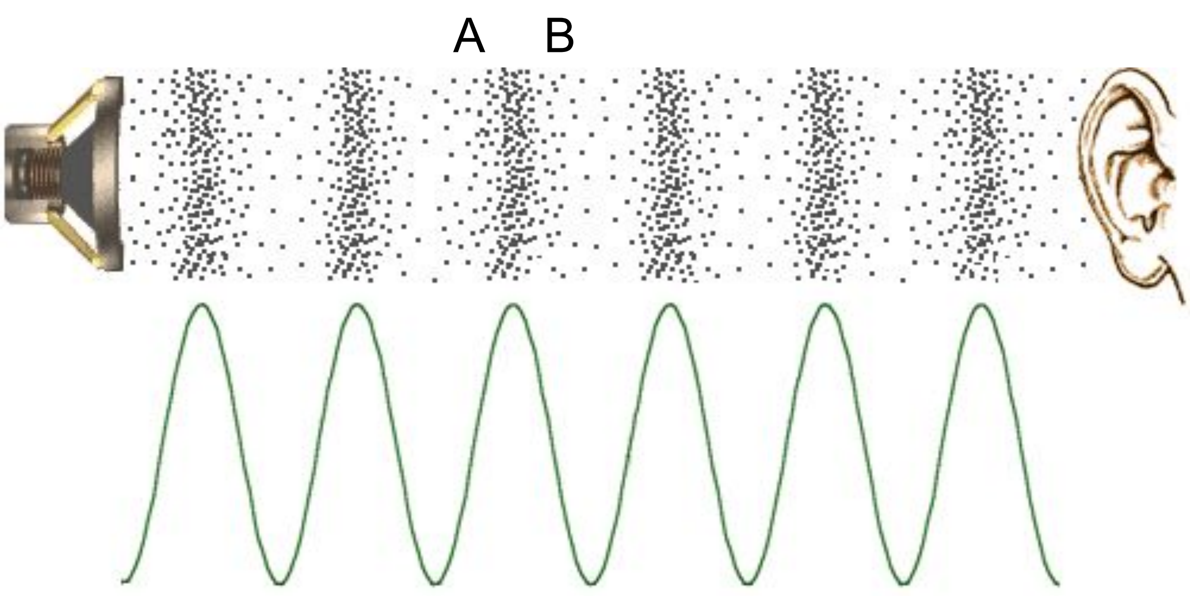
A) Left, Right

B) Left, Left

C) Right, Right

D) Right, Left

E) NOTA



https://www.youtube.com/watch?v=BKMD8vI1MaM

Based on the diagram, which are maximum at the piston?

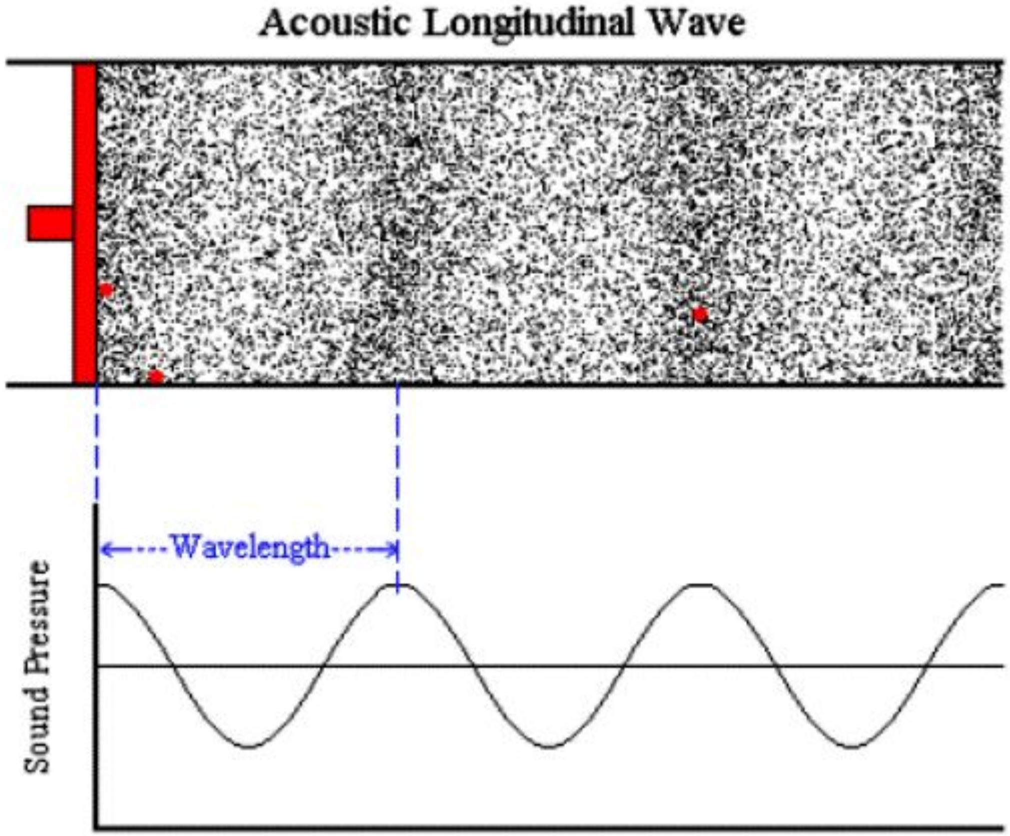
A) P, ρ, v

B) P and v only

C) P and ρ only

D) v and ρ only

E) NOTA



A 16 cm pipe is closed at one end. What is the fundamental resonant frequency of sound waves in the pipe (c_0=330 m/s)?

A) 1031.5 Hz

B) 2062.5 Hz

C) 515.6 Hz

D) 1547.1 Hz

E) NOTA

Same question, 1st harmonic...

Same question, open/open fundamental

Laika howls as he runs past Buzz Aldrin. What is the relative ranking of the relative frequencies, as heard by Buzz?

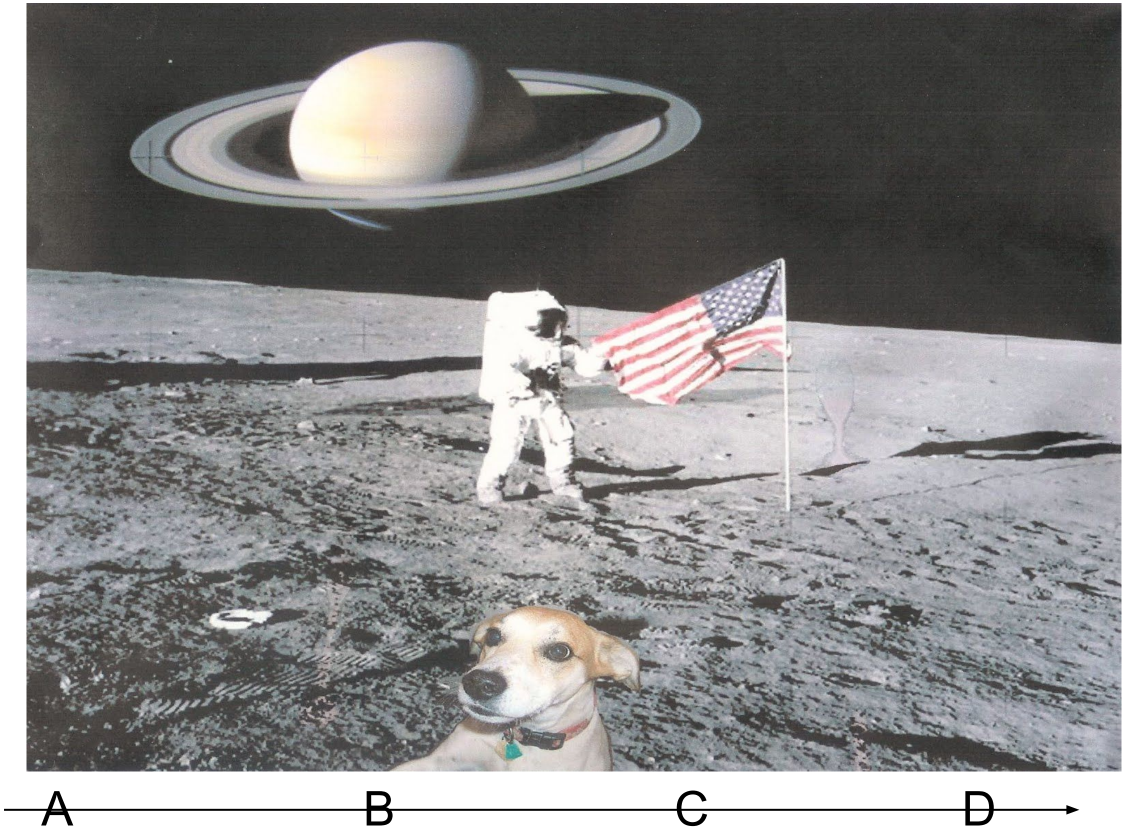
A) $f_A=f_B=f_C=f_D$

B) $f_A=f_B>f_C=f_D$

C) $f_A=f_B<f_C=f_D$

D) $f_A>f_B>f_C>f_D$

E) NOTA



An LPD officer, seeing a badly frostbitten cyclist on Mass St., sets in pursuit in order to save the suspect from his own poor judgment. The cyclist, realizing that “Impersonating a physics professor” is a class-2 felony in Kansas, decides to make a break for Oklahoma, and bolts South on Mass St. at 33 m/s. What is the wavelength of the siren heard by the rogue faux Prof., if the LPD officer approaches at 16.5 m/s and the car siren's frequency is that of a low A (f_0=110 Hz)?

A) 2.7 m

B) 2.85 m

C) 3.15 m

D) 3.3 m

E) NOTA

LAWRENCE & ST

LAWRENCE JOURNAL-WORLD • LJWorld.com/local • Monday

Mike Yoder/Journal-World Photo

A BICYCLIST PASSES THROUGH SOUTH PARK Sunday morning on his way downtown. A winter storm from Saturday

A train whistle emits sound at f_0=440 Hz. What is the beat frequency perceived if train 1 moves towards a platform at 6.6 m/s and a 2nd moves away at 3.3 m/s? Use $c_{sound, 0}$=330 m/s

A) 9.9 Hz

B) 9.6 Hz

C) 13.2 Hz

D) 6.6 Hz

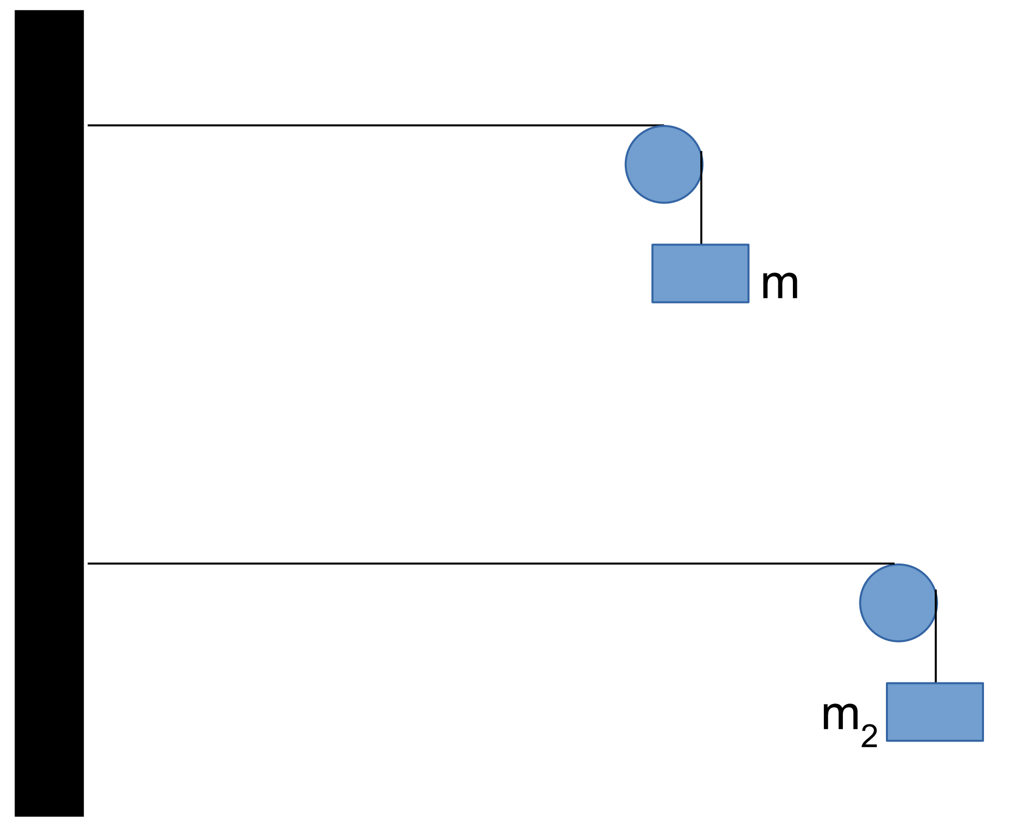
E) NOTA

Given the two strings below vibrating in their fundamental mode; how does the beat frequency f_B change as the mass m_2 increases from its initial value of m?

A) f_B increases

B) f_B decreases

C) f_B unchanged



Crash course on cosmology

According to the Big Bang model, the Universe is how old?

A) 1 Gyr
B) 5 Gyr
C) 13 Gyr
D) 20 Gyr

In the BB model:

A) The Universe began very 'bright' and has been slowly dimming

B) The U began dim and has been slowly 'brightening'

C) The U began bright, then went dark, then slowly filled with light again

In the BB model, the U

A) Begins as a point, which then grows spherically outwards

B) Starts “infinite” in size, then gets bigger

C) Starts “infinite” in size, with no change in volume since creation

The furthest objects in our solar system are about:

A) 1/1000 of the way to the nearest star

B) 1% of the way to the nearest star

C) 25% of the way to the nearest star

The fastest-moving, and most distant galaxies currently recede from the Milky Way at a velocity

A) 0.01% of the speed of light

B) 1% of the speed of light

C) About at the speed of light

D) Greater than the speed of light

Within about 5 billion years

A) The Sun will expand and eventually re-define "Global Warming" (thereby obliterating any life that may have survived that long)

B) A nearby star (within about 20 l-yr) will supernova (producing a lethal rain of cosmic rays and thereby obliterating any life that may have survived that long)

C) The galaxy Andromeda will collide with the Milky Way; the merger of their central black holes will produce a distortion of space-time kinda like a funhouse mirror (also producing a lethal rain of cosmic rays and thereby obliterating any life that may have survived that long)

As time goes on... (beyond the Andromeda/Milky Way merger)

A) The night sky will get increasingly bright

B) The night sky will remain about as bright as it is now

C) The night sky will become increasingly dark, and eventually lightless

Like phsx 114, this is the way the world ends:

A) With a bang

B) Not with a bang, but a whimper...