Physics 101 Exam 1 Solutions

October 12, 2016

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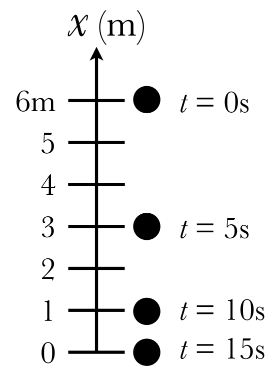
1. The figure shows the motion diagram of a ball. We'll say that "up" is the $+x$ direction.



$\boxed{3}$ (a) **D** Which of the following describes this motion?

A) Moving up, and getting faster
B) Moving up, and getting slower
C) Moving down, and getting faster
D) Moving down, and getting slower

$\boxed{2}$ (b) **A** What direction does the ball's acceleration point?

A) ↑ **B)** ↓

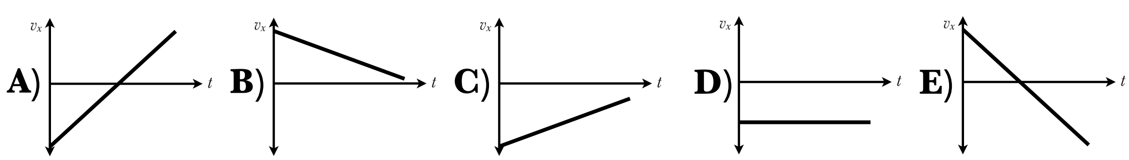
$\boxed{3}$ (c) What is the displacement Δx between $t = 5\,\mathrm{s}$ and $t = 10\,\mathrm{s}$?

$$\Delta x = x_f - x_i = -(2m)\hat{x}$$

$\boxed{3}$ (d) What is the velocity v between $t = 5\,\mathrm{s}$ and $t = 10\,\mathrm{s}$?

$$v = \frac{\Delta x}{\Delta t} = \frac{-(2m)\hat{x}}{5\,\mathrm{s}} = 0.4\,\mathrm{m/s}(-\hat{x})$$

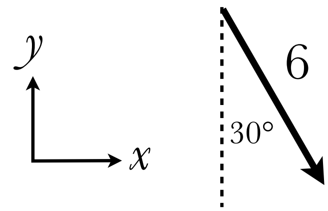
$\boxed{3}$ (e) **C** Which of the following is the graph of the velocity v_x of this object, as a function of time?



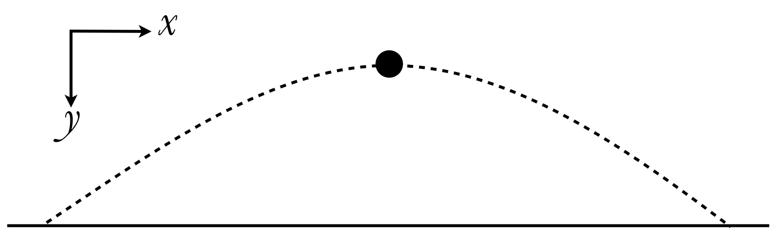
$\boxed{3}$ 2. C Which of these describes the vector shown?

A) $6\sin 30°\hat{x} + 6\cos 30°\hat{y}$ **B)** $6\cos 30°\hat{x} + 6\sin 30°\hat{y}$

C) $6\sin 30°\hat{x} - 6\cos 30°\hat{y}$ **D)** $6\cos 30°\hat{x} - 6\sin 30°\hat{y}$



3. A ball is thrown through the air as shown. *Note the axes!*



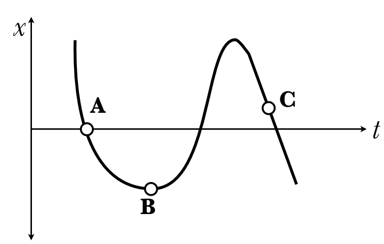
$\boxed{3}$ (a) B What is true about the velocity of the ball at the top of its flight?

A) $v_x = 0$ **B)** $v_y = 0$ **C)** Both of these **D)** Neither of these

$\boxed{3}$ (b) B What is the acceleration $\vec{a}$ of the ball at the top of its flight?

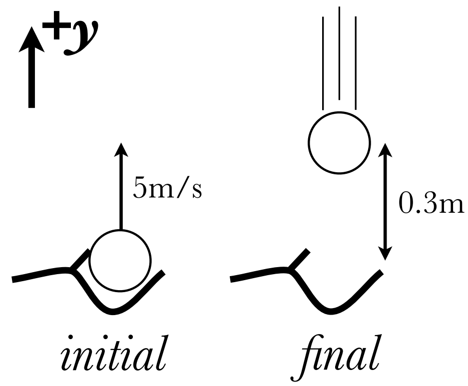
A) $0\,\mathrm{m/s^2}$ **B)** $9.8\hat{y}\,\mathrm{m/s^2}$ **C)** $-9.8\hat{y}\,\mathrm{m/s^2}$ **D)** None of these.

$\boxed{3}$ 4. C The figure shows the position of an object with respect to time. At which point is the acceleration zero?



5. A ball is thrown directly into the air with an initial speed of 5 m/s. It reaches a maximum height, and then begins to fall back down. We want to calculate the ball's velocity when it is 0.3 m above the hand (and moving downward).

Δy	0.3m
v_{iy}	5m/s
v_{fy}	
a	-9.8m/s^2
Δt	



$\boxed{3}$ (a) Fill in the table with the information that's given. Write "NEED" next to the variable you want to solve for.

$\boxed{3}$ (b) Find the velocity requested.

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$v_f = \pm\sqrt{(5)^2 + 2(9.8)(0.3)}$$

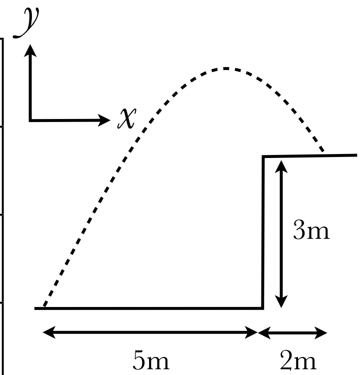
$$v_f = \boxed{-4.4\,\text{m/s}}$$

Choose the negative value because it's moving down.

6. A cannonball is fired from ground level and lands on top of a building that is 3 m high, and 5 m away; the ball lands 2 m away from the edge of the building. When the ball lands, the horizontal component of its velocity is $v_{fx} = 2\,\mathrm{m/s}$.

Δx	7m	Δy	3m
v_{ix}		v_{iy}	
v_{fx}	**2 m/s**	v_{fy}	
a_x	$0\mathrm{m/s^2}$	a_y	$-9.8\mathrm{m/s^2}$

Δt	



$\boxed{4}$ (a) Fill in the above table with what you're given by the problem.

$\boxed{3}$ (b) Find the time it takes for the ball to land.
Use the x column.

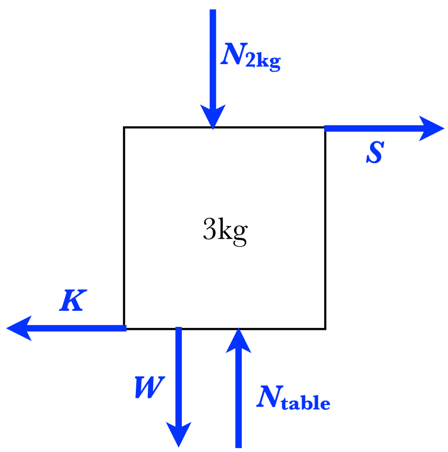
$$\Delta x = v_{fx}\Delta t - \frac{1}{2}a(\Delta t)^2$$

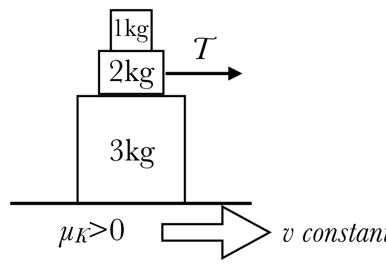
$$7 = 2\Delta t - 0 \implies \Delta t = \boxed{3.5\,\mathrm{s}}$$

$\boxed{3}$ (c) What is the speed $|v|$ of the ball at the very top of its flight? (You don't need to answer part (b) to answer this.)

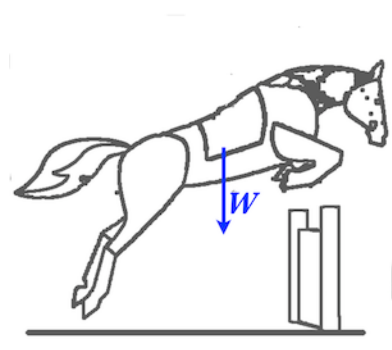
The vertical component of the velocity is zero, but the horizontal component of the velocity remains a constant $2\,\mathrm{m/s}$. Thus the velocity at the top of the flight is $2\hat{x}\,\mathrm{m/s}$, and the speed is $\boxed{2\,\mathrm{m/s}}$.

$\boxed{3}$ 7. The right figure shows a stack of three blocks that are being dragged along a table by a rope that's attached to the middle block. There is friction between all surfaces, but disregard air resistance. Draw all the forces that are acting on the separate 3 kg block below. Label these with letters such as W, N, etc, and if there are multiple forces of the same type, indicate what object is exerting the force as a subscript. (e.g. "$N_{1\,\mathrm{kg}}$" for a normal force from the 1 kg block).

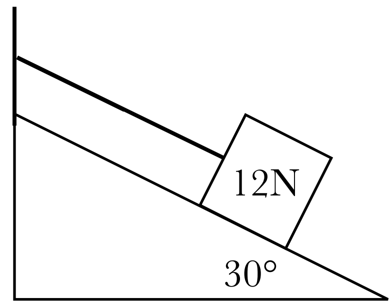




$\boxed{3}$ 8. A horse is jumping over a hurdle, having just left the ground. Label the forces acting on the horse. Ignore air resistance.



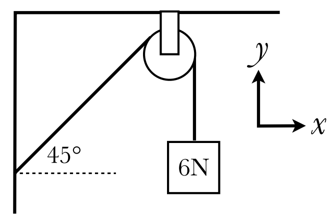
$\boxed{3}$ 9. **B** A box of weight $W = 12\,\mathrm{N}$ is suspended on a frictionless ramp by a rope. The ramp makes a $30°$ angle with the horizontal. Find the tension in the rope.
A) 4 N **B)** 6 N **C)** 10 N **D)** 12 N



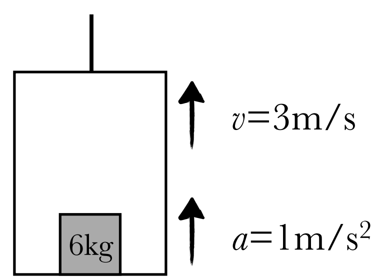
The tension in the rope opposes the component of gravity that points down the ramp, which is

$$W \sin 30° = (12\,\mathrm{N})(\frac{1}{2}) = 6\,\mathrm{N}$$

$\boxed{3}$ 10. **D** A $W = 6\,\mathrm{N}$ block is suspended from a rope, as shown, and is stationary. The rope runs over a pulley and attaches to a wall at a $45°$ angle. What is the tension in the rope?
A) 3 N **B)** 2.1 N **C)** 4.2 N **D)** 6 N **E)** 12 N



$\boxed{3}$ 11. **C** An elevator moves upward at $3\,\mathrm{m/s}$ and is accelerating upward at $1\,\mathrm{m/s^2}$. A 6 kg block (with a weight of 59 N) sits on the floor of the elevator. What is the normal force on the block due to the floor of the elevator?
A) 53 N **B)** 59 N **C)** 65 N

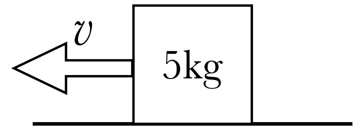


The net force (if up is positive) is $F_{net} = N - (6\,\mathrm{kg})(9.8\,\mathrm{m/s^2})$. This is equal to ma, so

$$N-(6\,\mathrm{kg})(9.8\,\mathrm{m/s^2}) = (6\,\mathrm{kg})(1\,\mathrm{m/s^2}) \implies N = (6\,\mathrm{kg})(9.8\,\mathrm{m/s^2}+1\,\mathrm{m/s^2}) = 65\,\mathrm{N}$$

12. A 5 kg block slides across a table to the left, and slows down due to friction.

$\boxed{3}$ (a) What is the weight of the block?



$$W = mg = (5\,\text{kg})(9.8\,\text{m/s}^2) = \boxed{49\,\text{N}}$$

$\boxed{3}$ (b) What is the force of kinetic friction on the block?

The normal force N balances the weight, so $N = 49\,\text{N}$, and the kinetic frictional force is $K = \mu_K N = (0.2)(49\,\text{N}) = \boxed{9.8\,\text{N}}$

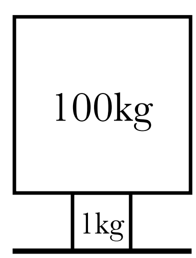
$\boxed{3}$ (c) What is the block's acceleration $\vec{a}$? Give magnitude and direction.

The net horizontal force on the block is K to the right, so the block's acceleration is

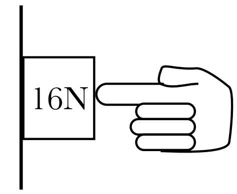
$$\vec{a} = \frac{\vec{F}}{m} = \frac{9.8\,\text{N} \rightarrow}{5\,\text{kg}} = \boxed{1.96\,\text{m/s}^2 \rightarrow}$$

$\boxed{3}$ 13. **C** A 100 kg block is balanced atop a 1 kg block. Which is the larger force?

A) The force of the 100 kg block on the 1 kg block
B) The force of the 1 kg block on the 100 kg block
C) Both forces have the same magnitude



14. A $W = 16\,\mathrm{N}$ block is pressed against a wall by a finger as shown, and is stationary. The coefficient of static friction between wall and block is $\mu_S = 0.4$.



$\boxed{3}$ (a) **C** What is the static frictional force S on the block from the wall?

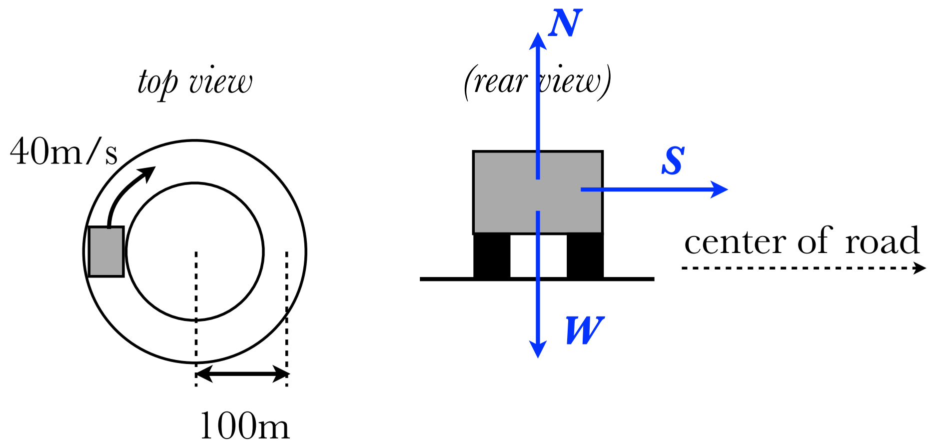
A) $0.4\,\mathrm{N}$ **B)** $6.4\,\mathrm{N}$ **C)** $16\,\mathrm{N}$ **D)** $40\,\mathrm{N}$

$\boxed{3}$ (b) **C** What force must the finger exert on the block, so that it doesn't slip?

A) at least $16\,\mathrm{N}$
B) at least $25\,\mathrm{N}$
C) at least $40\,\mathrm{N}$
D) it doesn't matter; any force will do

The maximum static frictional force is $\mu_S N$. If the static frictional force is $16\,\mathrm{N}$, then $16\,\mathrm{N} \leq 0.4N \implies N \geq 40\,\mathrm{N}$.

15. The figure shows a car driving around a circular track with radius 100 m, at a constant speed of 40 m/s.



$\boxed{3}$ (a) Draw the forces acting on the car in the figure marked "rear view". Ignore any forces that point into or out of the page.

$\boxed{3}$ (b) **F** What is the car's acceleration in the "rear view" figure?

A) $0\,\mathrm{m/s^2}$
B) $9.8\,\mathrm{m/s^2} \leftarrow$ **C)** $9.8\,\mathrm{m/s^2} \rightarrow$ **D)** $9.8\,\mathrm{m/s^2} \downarrow$
E) $16\,\mathrm{m/s^2} \leftarrow$ **F)** $16\,\mathrm{m/s^2} \rightarrow$

The car is moving in a circle so its acceleration is

$$a = \frac{v^2}{r} = \frac{(40\,\mathrm{m/s})^2}{100\,\mathrm{m}} = 16\,\mathrm{m/s^2}$$

towards the center of the circle, to the right.