Fall 2008 RED Barcode Here

Physics 105, sections 1 and 2

Exam 1 Please write your CID_____

Colton 2-3669

3 hour time limit. One 3″ × 5″ <u>handwritten</u> note card permitted (both sides). Calculators permitted. No books.

Constants: $g = 9.80\ \text{m/s}^2$

Quadratic formula: $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Keep four significant digits throughout your calculations; do not round up to less than four. When data is given, assume it has at least four significant digits. For example "15 meters" means 15.00 meters.

The problems are labeled with a question mark in brackets; [1?] means the answer goes in bubble sheet #1.

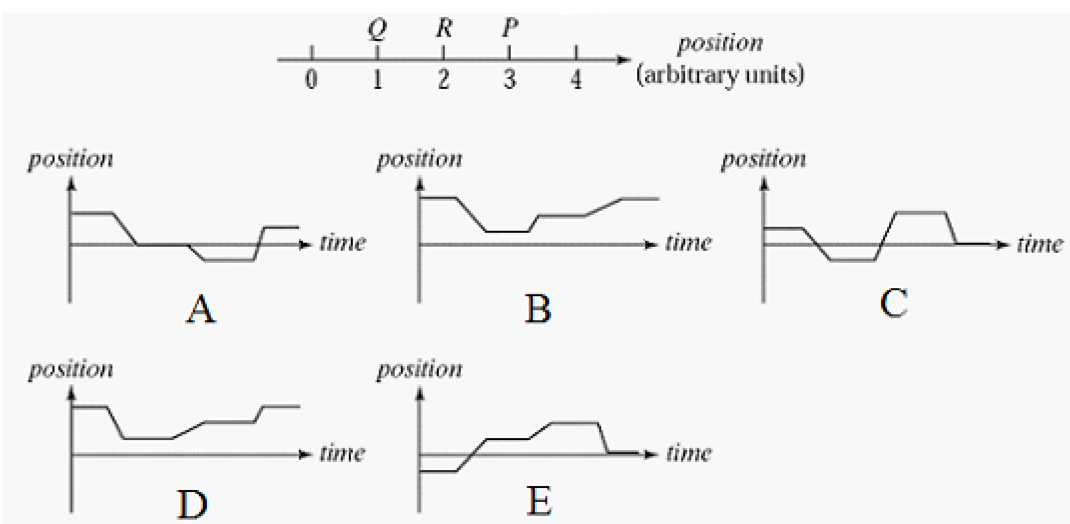
You are strongly encouraged to **write your work on the exam pages and write your answers into the answer blanks** (but of course also **record your final answers on the bubble sheet**).

Make sure your calculator is in DEGREES, not radians.

→Write your CID above upper right corner. Did you do this ________? You won't get your exam back without writing your CID.

In all problems, ignore the effects of air resistance.

Nancy, initially at point P in the illustration, stays there a moment and then moves along the axis to Q and stays there a moment. She then walks slowly to R, stays there a moment, and then walks quickly back to P. Which of the $x(t)$ graphs below correctly represents this motion? [1?] ______



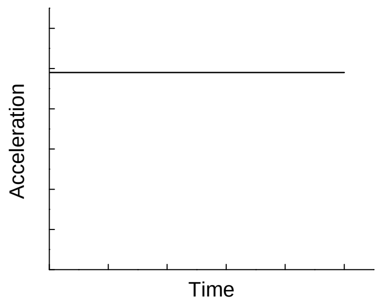
What was Nancy's total displacement for the trip? [2?] _____ (a) -4 units (b) -3 (c) -2 (d) -1 (e) 0 (f) 1 (g) 2 (h) 3 (i) 4 units

1. The first slope should go down, since she is moving left, or in a negative direction. The next two slopes are positive, since she is moving to the right. The first should be a more gradual slope, since she moves slowly, while the other is steep because she moves quickly. (d)
2. $\Delta x = x_f - x_i$; Her total displacement is 0 because she ends at the origin (e)

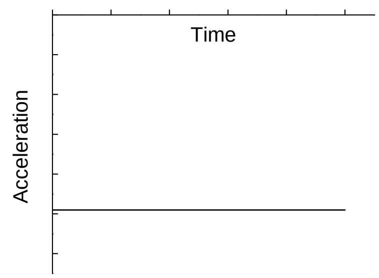
Sally throws a ball upwards at a 5° angle from the horizontal. Her twin sister Susie throws a similar ball at the same time with the same speed, but upwards at a 10° angle. Whose ball hits the ground first? [3?] _____ (a) Sally's (b) Susie's (c) They hit at the same time (d) It is impossible to tell with the given information.

3. The smaller angle has less v_{0y}, initial upward velocity. It will therefore reach a smaller height and will also hit the ground first. (a)

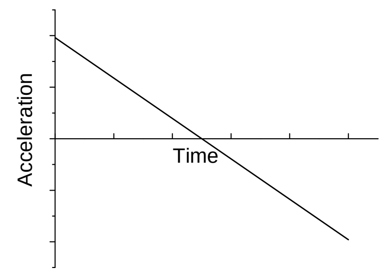
You throw a ball vertically in the air. Its acceleration is plotted, beginning just after it leaves your hand. Which of the following is the correct plot (up = positive direction)? [4?] _____



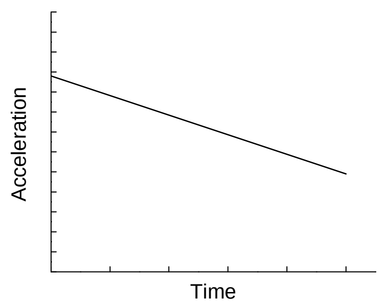
(a)



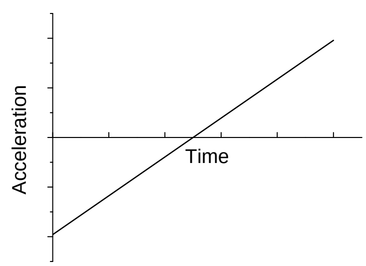
(b)



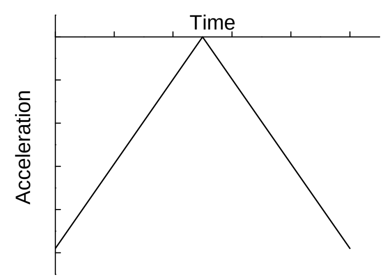
(c)



(d)



(e)



(f)

4. As soon as the ball leaves your hand, the only acceleration acting on it is gravity. $g=-9.8 m/s^2$ (b)

A car is moving to the left at constant speed. The acceleration is [5?]_______ (a) to the right (b) to the left (c) zero. It now puts on its brakes (while still moving left). The acceleration is [6?]_______ (a) to the right (b) to the left (c) zero.

5. When moving at a constant speed, acceleration is zero. (c)
6. The brakes cause acceleration opposite the velocity of the car. (a)

In the "milk drop demo", drops of a white liquid fell freely while being illuminated by a strobe light. What statement is accurate? [7?] ____ (a) The illuminated drops were evenly spaced. (b) The illuminated drops were spaced closer together at the bottom. (c) The illuminated drops were spaced closer together at the top.

7. The drops are accelerating downward, so they are going slowest at the top (c)

A bus is going at speed v_0 and slows down at a constant rate until it stops. If it takes t seconds to come to a complete stop, what was the acceleration of the bus during this time? [8?] _____ (a) $-v_0/t$ (b) $-(v_0/t)^2$ (c) $-v_0^2/t$ (d) $-v_0/t^2$

8. $v_f=v_0+at$, $v_0=0$
$0=v_0+at$, $a=-v_0/t$ (a)

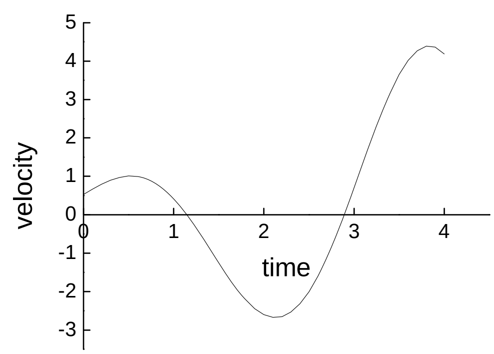
To find out how deep a well is, you drop a rock. You hear the splash 1.7 seconds later. How deep was the well? (Assume that the sound travels back to you essentially instantaneously.) [9?] _____ (a) less than 13.3 m (b) between 13.3 and 13.4 (c) between 13.4 and 13.5 (d) between 13.5 and 13.6 (e) between 13.6 and 13.7 (f) between 13.7 and 13.8 (g) between 13.8 and 13.9 (h) between 13.9 and 14.0 (i) between 14.0 and 14.1 (j) deeper than 14.1 m.

9. $y=y_0 + v_{0y}t - 1/2gt^2$
$y=0 + 0 - 1/2(9.8)(1.7)^2 = 14.16$ m (j)

A jet plane lands with a speed of 45 m/s and can decelerate (slow down) at a maximum acceleration magnitude of 6.5 m/s^2 as it comes to rest. From the instant the plane touches the runway, what is the minimum distance needed for the plane to stop? [10?] _____ (a) less than 153.8 m (b) between 153.8 and 154.5 (c) between 154.5 and 155.2 (d) between 155.2 and 155.9 (e) between 155.9 and 156.6 (f) between 156.6 and 157.3 (g) between 157.3 and 158.0 (h) longer than 158.0 m.

10. $v_f^2 = v_0^2 + 2a\Delta x$
$0 = 45^2 + 2(-6.5)\Delta x$
$\Delta x = 45^2/2(6.5) = 155.77$ m (d)

A block has the velocity vs time graph given in the figure, the positive direction meaning "to the right". How many times did the block turn around during this period of time? [11?] _____ (fill in number in bubble sheet)



11. A change in direction is indicated by the line crossing the x-axis (velocity going from positive to negative, or vice versa). (2)

Approximately what fraction of the time was the block moving to the left? [12?] _____ (a) 0-8% (b) 8-16% (c) 16-24% (d) 24-32% (e) 32-40% (f) 40-48% (g) 48-56% (h) 56-64% (i) 64-72% (j) 72-80%

12. The block was moving left when its velocity was negative, or from roughly 1.1 to 2.9; ≅1.8/4 or roughly 45% of the time (f)

A runner runs at a steady 15 km/hr. When the runner is 7 km from the finish line, a bird begins flying from the runner to the finish at 23 km/hr. When the bird reaches the finish line, it turns around and flies back to the runner, and then turns around again, repeating the back-and-forth trips from the finish line to the runner until the runner reaches the finish line. How many kilometers does the bird travel? [13?] _____ (a) less than 9.6 km (b) between 9.6 and 9.8 (c) between 9.8 and 10.0 (d) between 10.0 and 10.2 (e) between 10.2 and 10.4 (f) between 10.4 and 10.6 (g) between 10.6 and 10.8 (h) more than 10.8 km. [*Hint*: How long does it take the runner to finish? The bird was flying during this whole time.]

13. $x = vt \rightarrow$ Time to finish $= x/v = 7/15$ hours
bird's distance in that time $= vt = (23\text{km/hr})(7/15\text{ hr}) = 10.73$ km (g)

You enter the freeway and travel at a constant speed of 60 mi/hr to drive to a concert in Logan. Your roommate enters the freeway 15 minutes later traveling at a constant speed of 70 mi/hr going to the same concert. When your roommate passes you, you have gone how far (total) on the freeway [14?] _______ (a) less than 10 miles (b) between 10 and 20 (c) between 20 and 30 (d) between 30 and 40 (e) between 40 and 50 (f) between 50 and 60 (g) between 60 and 70 (h) between 70 and 80 (i) greater than 80 miles.

14. your lead: x = vt = 60mi/hr*1/4hr = 15 mi
gap narrows at 10 mi/hr, takes t = 15mi/(10mi/hr) = 1.5 hrs
you go additional distance vt = (60mi/hr)(1.5hrs) = 90mi
total distance = lead + additional distance = 15mi + 90mi = 105mi (i)

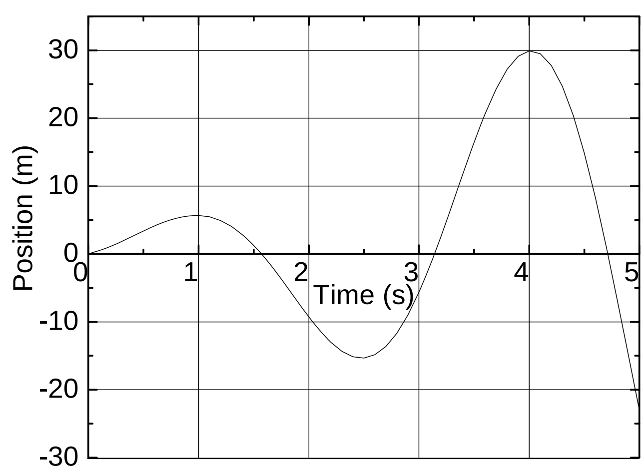
A sports car accelerates with 0.9 *g*'s. How long does it take the car to go from 20 m/s (44.7 mph) to 25 m/s (55.9 mph)? [15?] _____ (a) less than 0.24 s (b) between 0.24 and 0.29 (c) between 0.29 and 0.34 (d) between 0.34 and 0.39 (e) between 0.39 and 0.44 (f) between 0.44 and 0.49 (g) between 0.49 and 0.54 (h) longer than 0.54 s.

15. $\mathbf{v_f = v_0 + at}$
$\mathbf{25 = 20 + (.9)(9.8)t}$
$\mathbf{t = 5/(.9\cdot 9.8) = 0.5669\ s\ (h)}$

How much distance does it cover in that time? [16?] _____ (a) less than 12.7 m (b) between 12.7 and 12.8 (c) between 12.8 and 12.9 (d) between 12.9 and 13.0 (e) between 13.0 and 13.1 (f) between 13.1 and 13.2 (g) between 13.2 and 13.3 (h) between 13.3 and 13.4 (i) more than 13.4 m.

16. $\mathbf{v_f^2 = v_0^2 + 2a\Delta x}$
$\mathbf{25^2 = 20^2 + 2(0.9)(9.8)\Delta x}$
$\mathbf{\Delta x = (25^2 - 20^2)/(2\cdot 0.9\cdot 9.8) = 12.755\ m/s\ \ (b)}$

The graph of an object's position vs. time is given to the right. Estimate values from the graph to answer the following questions.



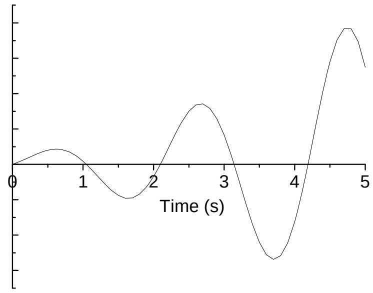
What is the average velocity between 1 and 2 seconds? [17?] ____ (a) less than -12 m/s (b) between -12 and -8 (c) between -8 and -4 (d) between -4 and 0 (e) between 0 and 4 (f) between 4 and 8 (g) between 8 and 12 (h) greater than 12 m/s.

17. The average velocity is the slope (rise over run) in this part of the graph. At 1 second, the line is approximately at 5, and at 2 seconds it is at roughly -10. The slope is "rise over run", which is -15/1. (a)

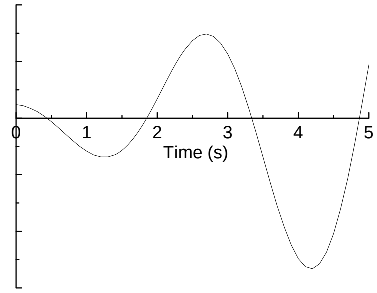
What is the instantaneous velocity at 3.5 seconds? [18?] _____ (a) less than -50 m/s (b) between -50 and -30 (c) between -30 and -10 (d) between -10 and 10 (e) between 10 and 30 (f) between 30 and 50 (g) greater than 50 m/s

18. The instantaneous velocity is found by drawing a line tangent to the curve at the 3.5 seconds mark. This line has approximate points at (4, 36) and (3, -5). Thus, "rise over run" is (36-(-5))/(4-3), or roughly 41 m/s. (f)

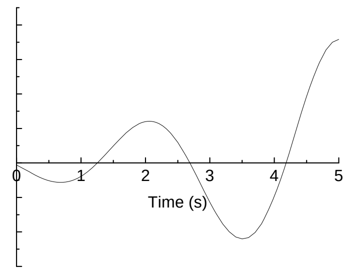
Which of the following corresponds to the velocity vs. time graph for the object? [19?] _____
Which corresponds to the acceleration vs. time graph? [20?] _____



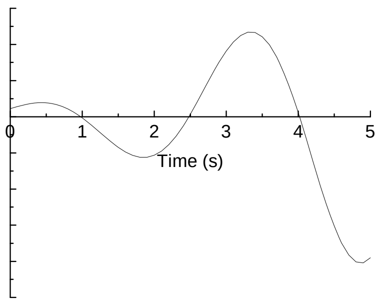
(a)



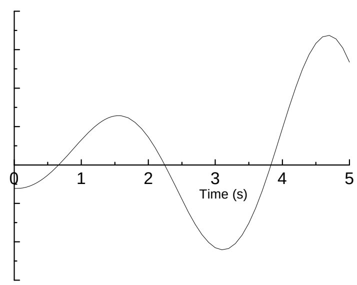
(b)



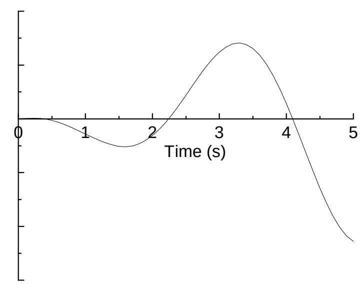
(c)



(d)



(e)

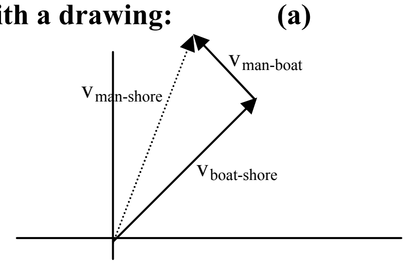


(f)

19. The velocity v. time graph needs to be zero at 1, 2.5, and 4 since those are the points where the position v. time graph shows a change in velocity from positive to negative or vice versa. (d)
20. The acceleration v. time graph should have zeroes at .4, 1.8, and 3.3 because those are the peaks on the velocity v. time graph. These peaks represent a change in acceleration from positive to negative or vice versa. (b)

A man is walking on a boat. The boat is facing exactly north-east, and traveling in that direction at 10 mph relative to the shore. The man is walking on the boat, at 4 mph. He is facing in such a direction that if the boat were standing still, he would be walking exactly northwest. Relative to the shore, in which general direction is the man walking? [21?] _____ (a) northeast (b) northwest (c) southwest (d) southeast.

21. This is easiest to visualize with a drawing: (a)



Relative to the shore, how fast is the man walking? [22?] _____ (a) less than 10.9 m/s (b) between 10.9 and 11 (c) between 11 and 11.1 (d) between 11.2 and 11.3 (e) between 11.3 and 11.4 (f) faster than 11.4 m/s

22. This answer is found through vector addition:

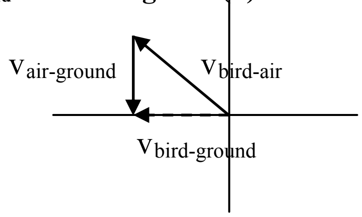
	x	**y**
$\mathbf{v_1}$	**10cos45**	**10sin45**
$\mathbf{v_2}$	**-4cos45**	**4cos45**
total	**4.243**	**9.899**

$$v_{tot}=\sqrt{v_x^2+v_y^2}$$
$$=\sqrt{4.243^2+9.899^2}$$
$$=10.77 \text{ mph} \quad \text{(a)}$$

Note: this is the one where the answer choices should have read "mph" instead of "m/s". If 10.77 mph is converted into m/s, it is 4.81 m/s. If you did this and marked answer a because of the unit conversion, please come talk to me individually.

A bird is flying in a wind of 5 m/s pointing south. The bird's airspeed (velocity of bird with respect to the moving air) is 8 m/s in some direction. A person on the ground sees the bird traveling due west. The general direction that the bird's head must be pointing in is [23?]_______ (a) N (b) NW (c) W (d) SW (e) S (f) SE (g) E (h) NE

23. The bird must be going NW if the southern wind causes it to end up flying due west. $v_{bird\text{-}ground} = v_{bird\text{-}air} + v_{air\text{-}ground}$. See the figure. (b)



The bird's speed with respect to the ground is [24?] ____ (a) less than 5.6 m/s (b) between 5.6 and 6.1 (c) between 6.1 and 6.6 (d) between 6.6 and 7.1 (e) between 7.1 and 7.6 (f) between 7.6 and 8.1 (g) between 8.1 and 8.6 (h) between 8.6 and 9.1 (i) between 9.1 and 9.6 (j) faster than 9.6 m/s.

24. $\mathbf{v_{bird\text{-}air}^2 = v_{bird\text{-}ground}^2 + v_{air\text{-}ground}^2}$

$\mathbf{v_{bg} = \sqrt{v_{ba}^2 - v_{ag}^2} = \sqrt{(8)^2 - (5)^2} = 6.245 m/s\ (c)}$

Bob and Marla each ride their bikes 10 miles to work, leaving at the same time. Bob has a flat ride, and can ride at 15 mph the whole way. Marla has a hill in the middle of her ride, so she rides at 10 mph for the first half (5 miles) and at 20 mph for the second half. Who gets to work first? [25?] _____ (a) Bob (b) Marla (c) They tie.

25. $\mathbf{x = vt \rightarrow t = x/v}$

$\mathbf{t_{Bob} = 10/15 = .67}$ **hours**

$\mathbf{t_{Marla} = 5/10 + 5/20 = .75}$ **hours (a)**

A cannonball is fired at a castle wall at a 30° angle from the horizontal, with an unknown initial speed. At exactly 3.5 seconds later, the ball hits the wall during the "on the way down" part of its trajectory. The ball leaves a hole in the wall 16.7 m off the ground. How fast was the ball fired? [26?] _____ (a) slower than 43.2 m/s (b) between 43.2 and 43.4 (c) between 43.4 and 43.6 (d) between 43.6 and 43.8 (e) between 43.8 and 44 (f) between 44 and 44.2 (g) between 44.2 and 44.4 (h) faster than 44.4 m/s

26. $\mathbf{y = y_0 + v_{0y}t - 1/2gt^2}$

$\mathbf{16.7 = (v_0 \sin 30)(35) - 1/2(9.8)(3.5)^2}$

$\mathbf{v_0 = 16.7 + 1/2(9.8)(3.5)^2/(3.5 \sin 30) = 43.84 m/s\ (e)}$

How far was the cannon from the base of the wall? [27?] _____ (a) closer than 132 m (b) between 132 and 133 (c) between 133 and 134 (d) between 134 and 135 (e) between 135 and 136 (f) between 136 and 137 (g) between 137 and 138 (h) farther than 138 m.

27. $\mathbf{x = x_0 + v_{0x}t}$

$\mathbf{d = (v_0 \cos 30)(3.5)}$

$\mathbf{d = (43.84 \cos 30)(3.5) = 132.89 m\ (b)}$

What was the ball's velocity just before it hit the wall? [28?] _____ (a) slower than 35.1 m/s (b) between 35.1 and 36.1 (c) between 36.1 and 37.1 (d) between 37.1 and 38.1 (e) between 38.1 and 39.1 (f) between 39.1 and 40.1 (g) between 40.1 and 41.1 (h) faster than 41.1 m/s.

28. $v_f = ?$

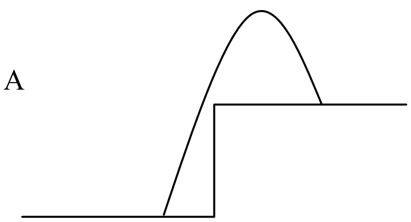
x: $v_{fx} = v_{ox} = 43.84\cos 30 = 37.97$ **m/s**

y: $v_{fy} = v_{0y} - gt = 43.84\sin 30 - (9.8)(3.5) = -12.38$ **m/s**

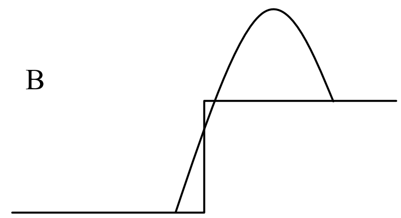
$v_f = \sqrt{v_x^2+v_y^2} = 39.93$ **m/s (f)**

A lady tries to throw a ball onto her apartment building's flat roof, 20 m above the height of her throwing arm. She stands 5.7 m from the base of the building and throws at a 77° angle from the horizontal. She throws the ball at 25 m/s. Does the throw clear the corner of the roof, as in figure A, or does it hit the corner, as in figure B? [29?] _____ (a) Clears the corner (b) Hits the corner.

A



B



29. What is the ball's height when x=5.7? Use time to connect x and y.

$x = v_0 + v_{ox}t$

$5.7 = 0 + 25\cos 77t$

$t = 5.7/25\cos 77 = 1.0136$ **s**

$y = y_0 + v_{0y}t - 1/2gt^2$

$y = 0 + (25\sin 77)(1.0136)-1/2(9.8)(1.0136)^2 = 19.656$ **m**

19.656 m < 20 m; the ball is not high enough to clear the corner (b)

Assuming that choice A is correct, or that the corner is rounded so that the ball misses the corner even if choice B is correct, how far horizontally does the ball travel from the lady before landing on the roof? [30?] _____ (a) less than 20.5 m (b) between 20.5 and 21.0 (c) between 21.0 and 21.5 (d) between 21.5 and 22.0 (e) between 22.0 and 22.5 (f) between 22.5 and 23.0 (g) between 23.0 and 23.5 (h) farther than 23.5 m

30. What is x when y = 20 at some later time?
Use time to connect x and y.

$x = v_0 + v_{ox}t$

$x = 0 + (25\cos 77)t$

use y to find t →

$y = y_0 + v_{0y}t - 1/2gt^2$

$20 = 0 + (25\sin 77)t - 1/2(9.8)t^2$

$4.9t^2 - 25\sin 77t + 20=0$

Use quadratic formula:

$t=(25\sin 77\pm\sqrt{(25\sin 77)^2-4(4.9)(20)})/(2\cdot 4.9)$

$t=(24.36\pm 14.19)/9.8$

$t=3.93366, t=1.0376$

We want the larger time because the smaller one corresponds to the *first* time the ball crosses y = 20 (that is, on the way up).

← plug t=3.934 back into the x equation

$x=(25\cos 77)(3.934)$

$x=22.122$ **m (e)**