INQUIRY PHYSICS - First Semester Review

Name________________________________

Your semester grade is determined by counting your accumulated semester classwork as 4/5 and the semester final as 1/5 of the final grade. The comprehensive semester test will cover all of the topics we have studied, including:

- one-dimensional motion
- vector math
- falling bodies
- projectile motion
- weight and mass
- Newton's laws & applications
- single & multiple force problems
- friction
- conservation of momentum

The semester test will consist of 22 multiple choice items. Consequently, partial credit will not be possible on this test. About half of the items are conceptual questions and half require some math calculations. The basic physics equations will be provided on the test, as shown on the practice final below.

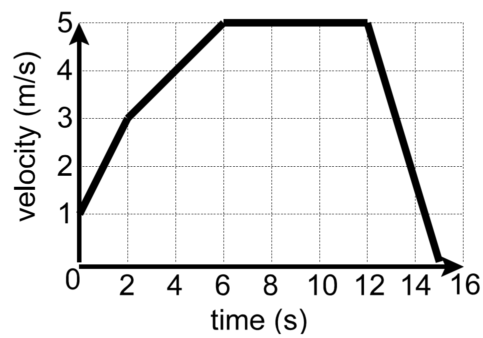
Complete the practice final; answers are given at the end. For any weak areas, review your old tests and quizzes and your notes.

PRACTICE FINAL **(Answers and error analysis are given at the end.)**

$$\vec{g} = -9.80 \text{ m/s}^2 \qquad a = \frac{v_f - v_i}{t} \qquad d = v_i t + \frac{1}{2} a t^2 \qquad v_f^{\,2} = v_i^{\,2} + 2ad \qquad p = mv$$

$$\bar{v} = \frac{d}{t} = \frac{v_i + v_f}{2} \qquad v_f = v_i + at \qquad t = \sqrt{\frac{2d}{a}} \text{ if } v_i = 0 \qquad \Sigma F = ma$$

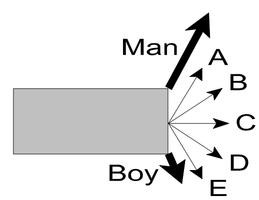
Refer to the one-dimensional v vs. t graph when answering questions 1-3.



_____ 1. What was the object's acceleration between t=0 s and t=2.0 s?
A) 3.0 m/s^2 B) 1.5 m/s^2 C) 1.0 m/s^2
D) 0.50 m/s^2 E) none of the above

_____ 2. How far did the object travel between t=2.0 s and t=6.0 s?
A) 32 m B) 16 m C) 8.0 m
D) 4.0 m E) none of the above

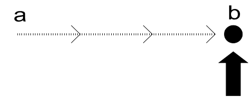
_____ 3. What was the object doing between t=12 s and t=15 s?
A) increasing its forward speed at a constant rate
B) maintaining a constant forward speed
C) decreasing its forward speed at a constant rate
D) maintaining a constant backward speed
E) decreasing its backward speed at a constant rate



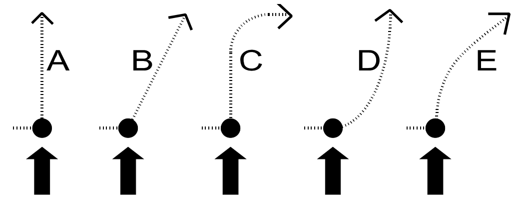
_____ 4. Two people, a large man and a boy, are pulling as hard as they can on two ropes attached to a crate as illustrated in the overhead view at right. Which of the indicated paths (A-E) would most likely correspond to the path of the crate as they pull it along?

_____ 5. Two steel balls, one of which weighs twice as much as the other, roll off of a horizontal table with the same speeds. In this situation, how does the horizontal distance d_{heavy} of the heavier ball from the base of the table compare to d_{light}, that of the lighter ball? (Assume air resistance is negligible.)
A) $d_{heavy} = d_{light}$ B) $d_{heavy} = 2d_{light}$ C) $d_{light} = 2d_{heavy}$ D) $d_{heavy} = 4d_{light}$ E) $d_{light} = 4d_{heavy}$

Use the statement and diagram below to answer questions 6-9:



The diagram depicts a hockey puck sliding eastward, with a constant velocity (v_i), from point "a" to point "b" along a frictionless horizontal surface, with negligible air resistance as well. When the puck reaches point "b", it receives an instantaneous horizontal "kick" northward.



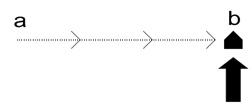
_____ 6. Along which of the paths at below right will the hockey puck move <u>after</u> receiving the "kick"?

_____ 7. What is the speed of the puck just <u>after</u> it receives the "kick"?
- A) same as v_i
- B) equal to the speed from the kick (v_{kick}), and independent of the initial speed v_i
- C) equal to the simple addition of speeds v_i and v_{kick}
- D) smaller than either v_i or v_{kick}
- E) greater than either v_i or v_{kick}, but smaller than the simple addition of the two

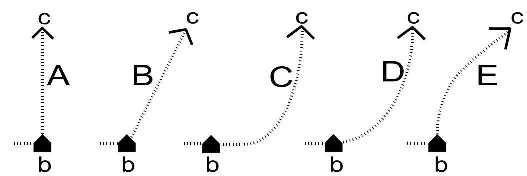
_____ 8. Along the frictionless path you have chosen, how does the speed of the puck vary <u>after</u> receiving the "kick"?
- A) no change
- B) continuously increasing
- C) continuously decreasing
- D) increasing for awhile, and decreasing later
- E) constant for awhile, decreasing later

_____ 9. The main forces acting <u>after</u> the "kick" on the puck along the path you have chosen are:
- A) downward force due to gravity
- B) downward force of gravity and horizontal force of momentum in the direction of motion
- C) downward force of gravity, upward force from surface, and a horizontal force in the direction of motion
- D) downward force of gravity and upward force from surface
- E) there are no forces acting after the kick

Use the statement and diagram below to answer questions 10-13:

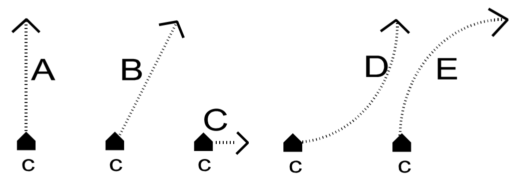


The diagram depicts a rocket, drifting sideways in outer space from position "a" to position "b", and subject to no outside forces. At "b", the rocket's engine starts to produce a constant thrust in the direction shown. The engine shuts off again as the rocket reaches some position "c".



_____ 10. Along which of the paths at below right will the rocket move between "b" and "c"?

_____ 11. As the rocket moves from "b" to "c", its <u>speed</u> is...
- A) constant
- B) continuously increasing
- C) continuously decreasing
- D) increasing for awhile and constant later
- E) constant for awhile and decreasing later

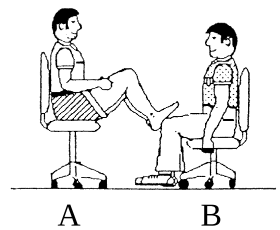


_____ 12. At "c" the rocket's engine is turned off. Which of the paths at right will the rocket follow beyond "c"?

_____ 13. Beyond "c", the speed of the rocket is:
- A) constant
- B) continuously increasing
- C) continuously decreasing
- D) increasing for awhile and constant later
- E) constant for awhile and decreasing later

_____ 14. A stone falling from the roof of a single story building to the earth...
- A) immediately reaches terminal velocity and then falls at a constant speed.
- B) speeds up as it falls, primarily because the closer it gets to earth, the stronger the gravitational pull.
- C) speeds up because of the constant gravitational force acting on it.
- D) falls because that is its inertial tendency.
- E) falls because of a combination of the force of gravity and the air pressure pushing it downward.

____ 15. Two students, student "A" who masses 95 kg and student "B" who masses 77 kg, sit in identical office chairs facing each other. Student "A" places his bare feet on student "B"'s knees, as shown. Student "A" then suddenly pushes outward with his feet, causing both chairs to move. In this situation...



A) neither student exerts a force on the other.
B) student "A" exerts a force on student "B", but "B" exerts no force on "A".
C) each student exerts a force on the other but "B" exerts the larger force.
D) each student exerts a force on the other but "A" exerts the larger force.
E) each student exerts the same amount of force on the other.

____ 16. In the situation from question 15...
A) each student accelerates an equal amount in opposing directions.
B) student "A" accelerates more than student "B".
C) student "B" accelerates more than student "A".
D) neither student accelerates.
E) student "A" accelerates, but student "B" doesn't.

____ 17. In the situation from question 15, after the push...
A) the total momentum of both students is still zero.
B) student "A" has more momentum than student "B".
C) student "B" has more momentum than student "A".
D) student "A" has lost momentum, while student "B" has gained momentum.
E) student "B" has lost momentum, while student "A" has gained momentum.

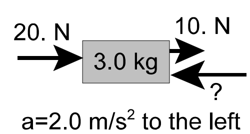
____ 18. A car takes 77.0 minutes to travel the 138 km of the Turner Turnpike. What is the car's average speed in m/s?
A) 179 m/s B) 33.5 m/s C) 29.9 m/s D) 1.79 m/s

____ 19. A balloon was falling at 5.00 m/s. A ballast bag fell from the balloon and hit the ground 50. m below. How much time did it take for the bag to reach the ground?
A) 2.72 s B) 3.19 s C) 3.75 s D) 10.0 s

____ 20. An AK-47 rifle has a 0.415 m long barrel and fires its bullets at 710. m/s. How much does it accelerate a bullet?
A) 855 m/s^2 B) 1710 m/s^2 C) 105,000 m/s^2 D) 607,000 m/s^2

____ 21. A car weighing 14,300 N is traveling at 30.0 m/s when it is steadily braked to a stop in 12.0 s. What was the braking force?
A) 3,650 N B) 10,700 N C) 35,800 N D) 525,000 N

____ 22. What is the magnitude of the missing force vector in the figure at right, if the 3 kg block is to accelerate left at 2 m/s^2?

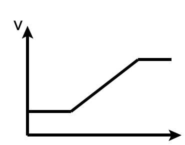


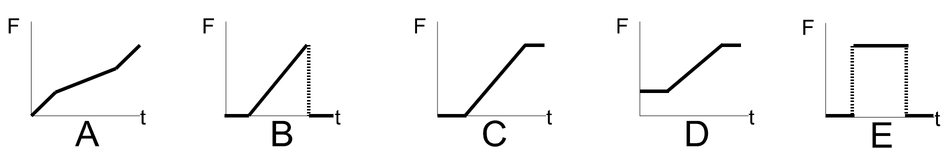
A) 6.0 N B) 16 N
C) 24 N D) 36 N

____ 23. A package with a mass of 5.00 kg is lifted upward at 2.00 m/s^2. What is the upward pull on the package?
A) 147 N B) 59.0 N C) 49.0 N D) 39.0 N

____ 24. In which situation would the friction be the highest? (Assume the same tires in each case.)
A) A car is being driven at a constant speed on a level asphalt road.
B) A car accelerating backward on a level asphalt road is on the verge of skidding.
C) A car is skidding across a level asphalt road.
D) A car is a rest on a level asphalt road.

____ 25. The velocity of an object as a function of time is shown in the graph at right. Which graph below best represents the net force-vs.-time relationship for this object?



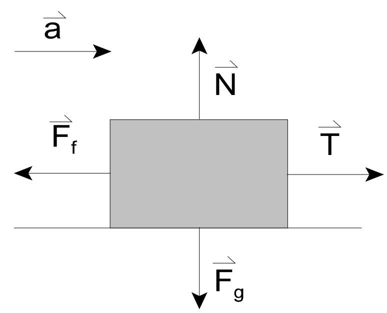


______ 26. A girl throws a steel ball straight up. Disregarding any effects of air resistance, the force(s) acting on the ball until it returns to the ground is (are):
A) its weight vertically downward along with a steadily decreasing upward force.
B) a steadily decreasing upward force once it leaves the hand until it reaches the top, after which there is a steadily increasing downward force of gravity as it approaches the earth
C) a constant downward force of gravity along with an upward force that steadily decreases until the ball reaches the top, after which there is only the downward force of gravity
D) only a constant downward force of gravity
E) none of the above, the ball falls back down to earth simply because that is its inertial tendency

______ 27. A large box is being pushed across the floor at a constant speed of 4.0 m/s by an applied horizontal force. What can you conclude about the forces acting on the box?
A) The applied force must be greater than its weight.
B) The applied force must be equal to the frictional force.
C) The applied force must be more than the frictional force.
D) External forces such as friction aren't relevant to the box's motion.
E) If the applied force is doubled, the speed will increase to a constant 8.0 m/s.

______ 28. If the force being applied to the box in question 27 is suddenly discontinued, the box will...
A) stop immediately.
B) continue at a constant speed for a very short time and then slow to a stop.
C) immediately start slowing to a stop.
D) continue at a constant speed.
E) increase its speed for a very short time, then start slowing to a stop.

______ 29. A person pulls a block across a rough horizontal surface with a constant forward **acceleration** (to the right) by applying a force **T** as shown in the diagram, where the arrows correctly show the directions but not necessarily the magnitudes of the various forces acting on the block. Which of the following relations among the force magnitudes F_g , F_f , N, and T must be true?



A) $T = F_f$ and $N = F_g$ B) $T > F_f$ and $F_g > N$
C) $T > F_f$ and $N = F_g$ D) $T < F_f$ and $N = F_g$
E) none of the above

______ 30. If a racing car travels 430 km in 3.0 hours, what is its average speed in m/s?
A) 40. m/s B) 140 m/s
C) 2400 m/s D) 140,000 m/s

______ 31. A rocket was rising at 10.0 m/s. A booster separated and hit the ground in 30.0 seconds. How high was the rocket when the booster separated?
A) 8820 m B) 153 m C) 4710 m D) 4110 m

______ 32. A gun is fired and the bullet exits the barrel at 500.0 m/s. If the bullet was accelerated at 1.80×10^5 m/s^2 while it was in the gun, how long is the gun barrel?
A) 6.94 m B) 0.00139 m C) 0.694 m D) 1.39 m

______ 33. A car weighing 7500.0 N is traveling at 30.0 m/s when it is steadily braked to a stop over a distance of 100.0 m. What was the braking force?
A) 3440 N B) 33800 N C) 6890 N D) 1130 N

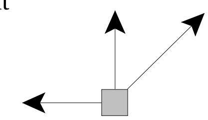
______ 34. What is the magnitude of the missing force vector in the figure at right, if the 5 kg block is to remain motionless?

A) 10 N B) 30 N
C) 50 N D) 70 N

______ 35. A rocket with a mass of 5,000 kg accelerates upward at 1.00 m/s^2 against the earth's gravity. What is the thrust?
A) 5,000 N B) 44,000 N C) 49,000 N D) 54,000 N

_____ 36. What is the acceleration of a projectile as it moves toward the top of its arc? (Assume no air resistance.)
A) 9.80 m/s^2 upward B) it varies with the initial velocity
C) 9.80 m/s^2 downward D) zero

_____ 37. Three forces are applied on an object as shown at right. What is the direction of the resultant force?
A) north B) 45° N of E C) west D) south

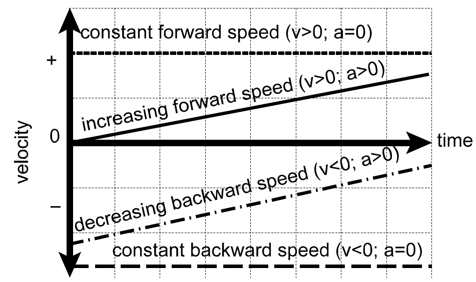


Answer Analysis

1. **C** Use $a = (v_f - v_i) / t$ = (3 m/s - 1 m/s) / (2 s) = (2 m/s) / (2 s) = 1.0 m/s^2 to find the answer. Or simply note that the slope of a v vs. t graph is acceleration.

2. **B** $d = \bar{v}\,t = \left(\frac{v_i + v_f}{2}\right)t = \left(\frac{3\,m/s + 5\,m/s}{2}\right)4\,s = 16\,m$

3. **C** The slopes of a v vs. t graph is acceleration; the slope between 12 and 15 seconds is constant but negative. Thus the object is accelerating negatively (backward) at a consta nt rate. The object is **not** moving backward, however, as it still has a **positive** velocity. It is merely slowing down. At right are the basic graph shapes that would fit the described motions.

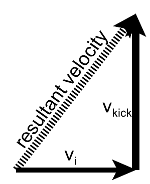


4. **B** This is a vector addition. The man pulls east and north, the boy pulls east and south. Thus the resultant definitely has an eastward part, and also a northward part since the man is stronger than the boy. (Answer A is aligned with the man's force, improperly ignoring the boy's effect.)

5. **A** The balls strike the ground simultaneously, because all objects accelerate downward at the same rate (in the absence of air drag). Thus they are both in the air for the same amount of time. The horizontal speeds remain constant due to inertia (there are no horizontal unbalanced forces), so the balls travel the same horizontal distance too.

6. **B** The kick adds a north velocity vector to the existing east one, creating a new northeast velocity vector. Answer A improperly assumes the last force to act determines the overall motion; the others assume the kick is somehow delayed or its effect is stretched out over a period of time (the medieval "impetus" misconception).

7. **E** The two velocity vectors add head-to-tail as shown at right. The hypotenuse is the resultant, and while it is longer than either side, it is not equal to the simple sum of the other sides.



8. **A** The puck must now maintain a constant velocity due to inertia. Answers B and D assume the force keeps acting, while C and E neglect the inertial tendency to maintain velocity.

9. **D** A force diagram could help you here (a box with arrows showing the forces and their directions). Answers B and C confuse motion with force; there is no horizontal force anymore. Answer E ignores the vertical forces which are always present in this situation.

10. **D** The rocket accelerates "north" while maintaining a constant velocity "east". Answer A ignores the remaining "eastward" velocity; B ignores the acceleration the continuous thrust produces; C delays the thrust; E incorrectly assumes that the original motion can somehow reassert itself.

11. **B** A continous force produces a continuous acceleration. Answer A confuses velocity with acceleration; C and E assume the force "wears out" or dissipates; D assumes terminal velocity when there is no air drag present.

12. **B** Rocket resumes a constant velocity after rocket shuts off; new velocity is a mixture of the old "eastward" velocity and new "northward" one. Answer A ignores the old velocity; C ignores the new velocity; D and E show an accelerating rocket even though the engine is off and the rocket is coasting.

13. **A** No net force yields constant velocity by the law of inertia.

14. **C** Answer A overestimates the effect of air resistance; B overestimates the effect of gravity change; D ignores the inertial tendency to maintain the current velocity; E ignores that air pressure acts equally in all directions.

15. **E** Third law of motion: each object exerts an equal and opposite force upon the other. Answer A ignores the applied forces; B ignores the reaction force; C errs by implying smaller masses cause larger forces; D errs by implying larger masses cause larger forces.

16. **C** Second law: when equal forces are applied, the smaller mass accelerates more.

17. **A** The push is an internal force and there are no external unbalanced forces if we ignore friction. So total momentum is conserved. Since each velocity was zero before the push, the total momentum was zero before and remains zero later. Both students "gained" momentum, with Student A having the same momentum to the left as Student B has to the right.

18. **C** $\bar{v} = \frac{d}{t} = \frac{138\text{ km}}{77\text{ min}}\left|\frac{1000\text{ m}}{\text{km}}\right|\frac{\text{min}}{60\text{ s}} = 29.870\text{ m/s} = 29.9\text{ m/s}$

19. **A** $v_f = \sqrt{v_i^2 + 2ad} = \sqrt{(-5\text{ m/s})^2 + (2)(-9.8\text{ m/s}^2)(-50)} = -31.702\text{ m/s}$

$$t = \frac{v_f - v_i}{a} = \frac{-31.702\text{ m/s} - (-5\text{ m/s})}{-9.8\text{ m/s}^2} = 2.7247\text{ s} = 2.72\text{ s}$$

20. **D** $a = \frac{v_f^2 - v_i^2}{2d} = \frac{(710\text{ m/s})^2 - 0}{2(0.415\text{ m})} = 607{,}350\text{ m/s}^2 = 607{,}000\text{ m/s}^2$

21. **A** $m = \frac{F_g}{g} = \frac{14{,}300\text{ N}}{9.8\text{ m/s}^2} = 1459.2\text{ kg}$

$$a = \frac{v_f - v_i}{t} = \frac{0 - 30\text{ m/s}}{12\text{ s}} = -2.5\text{ m/s}^2$$

$$F_x = ma_x = (1459.2\text{ kg})(-2.5\text{ m/s}^2) = -3648\text{ N} = 3650\text{ N backward}$$

22. **D** $\sum\mathbf{F}=m\mathbf{a}$ so +20 N +10 N + F = (3 kg)(-2 m/s^2) so F = – 6 N – 20 N – 10 N = – 36 N = 36 N left

23. **B** $\sum\mathbf{F}_y=m\mathbf{a}_y$ so $\mathbf{T} + \mathbf{F_g} = m\mathbf{a}_y$ so $\mathbf{T}$ = (5 kg)(2 m/s^2) – (m**g**) = 10 N – (5 kg)(-9.8 m/s^2) = 10 N + 49 N = 59.0 N

24. **B** Friction is zero in situation D and almost zero in situation A. Situation C involves kinetic friction, which is always less than the maximum available static friction. We know situation B has maximum static friction because the tire is not yet skidding, but is about to do so.

25. **E** The slope of v vs. t is acceleration. The slope (acceleration) is zero, then positive but constant, and then zero again. Thus the force, which is directly proportional to acceleration, also goes from zero to a positive constant value and then back to zero. Answer A has a force yielding no acceleration; B has an increasing force yielding constant acceleration; C and D have a combination of the errors made in A and B.

26. **D** The force of the hand disappears as soon as the ball leaves. Answers A, B, and C all assume the hand force somehow continues to act, which is not possible. Answer E incorrectly uses inertia; the ball's inertial tendency is to maintain its velocity at any given instant, but the unbalanced gravitational force won't allow that.

27. **B** Balanced forces yield constant velocity. Answer A improperly has a vertical force fighting a horizontal force; C improperly implies unbalanced forces are needed to maintain a motion; D confuses external forces with internal ones; E confuses velocity and acceleration while ignoring friction.

28. **C** Friction will now slow the box to a stop. Answer A wrongly assumes forces are required for movement; B wrongly assumes a delayed reaction either due to a dissipating force or inertia; D ignores friction; E is weird.

29. **C** The block is accelerating right, so there must be an unbalanced force to the right. Thus T > F_f. The block is <u>not</u> accelerating up or down, so the vertical forces must balance; N = W.

30. **A** $\bar{v} = \frac{d}{t} = \frac{430\,\text{km}}{3\,\text{h}}\left|\frac{1000\,\text{m}}{\text{km}}\right|\frac{\text{h}}{3600\,\text{s}} = 39.815\,\text{s} = 40.\ \text{s}$

31. **D** $d = v_i t + \frac{1}{2}at^2 = (10\,\text{m/s})(30\,\text{s}) + \frac{(-9.8\,\text{m/s}^2)(30\,\text{s})^2}{2} = -4110\,\text{m}$

32. **C** $d = \frac{v_f^2 - v_i^2}{2a} = \frac{(500\,\text{m/s})^2 - 0}{2(180{,}000\,\text{m/s}^2)} = 0.694\,\text{m}$

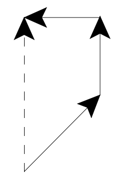
33. **A** $F = ma = \left(\frac{F_g}{g}\right)\left(\frac{v_f^2 - v_i^2}{2d}\right) = \left(\frac{7500\,\text{N}}{9.8\,\text{m/s}^2}\right)\left(\frac{0-(30\,\text{m/s})^2}{2(100\,\text{m})}\right) = (765.31\,\text{kg})(-4.5\,\text{m/s}^2) = -3440\,\text{N}$

34. **B** $\Sigma F = 0 = 20\,\text{N} + 10\,\text{N} + F \text{ so } F = -20\,\text{N} - 10\,\text{N} = -30\,\text{N}$

35. **D** $T = ma - \vec{F}_g = (5000\,\text{kg})(1\,\text{m/s}^2) - (5000\,\text{kg})(-9.8\,\text{m/s}^2) = 54{,}000\,\text{N}$

36. **C** All objects in freefall accelerate at 9.80 m/s^2 downward, regardless of their current velocity.

37. **A** Add the vectors by placing them head-to-tail (in any order) and then drawing a resultant from the tail of the first vector to the head of the last. At right, the resultant is the dashed arrow.



NUMERICAL PRACTICE PROBLEMS

To prepare for the mathematical multiple-choice questions on the semester exam, do the following problems. The answers are in the box below. Remember, the basic equations will be given on the test, which is all multiple choice.

ONE DIMENSIONAL MOTION

1. Mr. M was on top of the school building, leaning over the edge, when he lost one of his marbles. If the marble struck the pavement below after 2.00 seconds, how far did it drop?

2. Firemen are practicing rescue operations in which people would have to jump from tall buildings into a net. For this training exercise, a 200-pound ball is pushed off the top of the building. The top of the building is 78.4 meters above the net. How long will it take for the ball to fall to the level of the net?

3. An auto speeds up from 6.0 m/s to 20 m/s while covering 70 m. What acceleration did the car have?

4. An object moving at 13.0 m/s slowed uniformly at the rate of 2.00 m/s each second for a time of 6.00 seconds. What was the object's **average** speed during the 6.00 seconds?

Problems 5-7 relate to the following situation:
One day Wile E. Coyote fired himself from an Acme cannon straight upward into the air.

5. If the coyote left the cannon with an initial speed of 300 m/s, how long did it take him to reach his maximum height?
6. What was the maximum height?
7. How much time passed after the cannon was fired until the coyote's velocity was exactly 100 m/s upward?

VECTORS

8. A boy swims across a river with a constant velocity of 5.0 m/s west. The river current is 8.0 m/s north. What is his total velocity? *(draw the vectors to scale head-to-tail and measure the resultant)*

9. A woman walks 6.0 m east and then 8.0 m south. What is her displacement?

PROJECTILE MOTION

10. A projectile is fired horizontally from a tower at 200.0 m/s. It landed 1,500 m from the base of the tower. How far did it drop?

11. A bullet is fired horizontally from a height of 78.4 m and hits the ground 1,500 m away. With what velocity does the bullet leave the gun?

NEWTON'S LAWS OF MOTION AND THEIR APPLICATIONS

12. A rocket with a mass of 1,000 kg is fired from rest. If it accelerates upward against gravity at 5.00 m/s^2, how much thrust is the rocket motor providing?

13. A jet plane starts from rest down a runway and accelerates for takeoff at 2.00 m/s^2. The jet's engines provide a thrust of 125,000 N. What is the weight of the plane?

14. Velma Vector gunned her 1,200 kg car from rest to a speed of 30.0 m/s over a distance of 310 m. What was the accelerating force of her vehicle?

15. Mr. M was dragging his cat Fluffy out on a walk one day. Mr. M was pulling on Fluffy with a force of 12 N one way, while Fluffy was resisting with an opposing force of 8 N. If Fluffy had a mass of 5 kg, **how fast** and **in which direction** did Fluffy accelerate?

LINEAR MOMENTUM

16. Mr. M (mass 68.0 kg) was standing motionless in the road when a 1,000 kg truck skidded into him at 20.0 m/s. If Mr. M "stuck" to the truck, at what speed did the combination continue down the icy road?

17. Mr. M was shot out from a cannon. The cannon shot backward at a speed of 1.25 m/s. If Mr. M had a mass of 68.0 kg and was shot from the cannon with a speed of 155 m/s, what was the mass of the cannon?

Answers:
1. 19.6 m
2. 4.00 s
3. 2.6 m/s^2
4. 7.00 m/s
5. 30.6 s
6. 4590 m
7. 20.4 s
8. 9.4 m/s at 58° N of W
9. 10. m at 53° S of E
10. 275.6 m
11. 375 m/s
12. 14,800 N
13. 613,000 N
14. 1740 N
15. 0.8 m/s^2 towards Mr. M
16. 18.7 m/s
17. 8430 kg

