AP PHYSICS B - 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
friction

The semester test will consist of around twenty multiple choice items. Consequently, partial credit will not be possible on this test. The items will include both conceptual questions and math problems. The basic physics equations will be provided on the test.

Complete the practice final and then review your old test and quiz concept questions and your notes for any weak areas you identify.

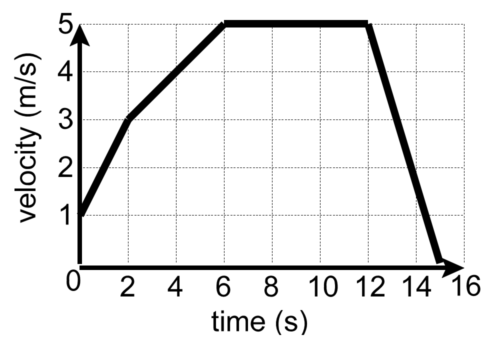
PRACTICE FINAL

(Answers and error analysis are given after the last question. Your final will be around 20 questions.)

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

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

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

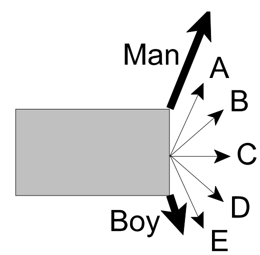


_____ 1. What was the object's average acceleration between t=0 s and t=2.0 s?
A) 3.0 m/s^2 B) 1.5 m/s^2 C) 1.0 m/s^2
D) 0.50 m/s^2 E) none of the above

_____ 2. How far did the object travel between t=0 s and t=6.0 s?
A) 20 m B) 8.0 m C) 6.0 m
D) 1.5 m E) none of the above

_____ 3. What was the average speed of the object for the first 6.0 s?
A) 3.3 m/s B) 3.0 m/s C) 1.8 m/s
D) 1.3 m/s E) none of the above

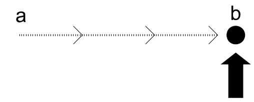
_____ 4. Two people, a large man and a boy, are pulling as hard as they can on two ropes attached to a crate as illustrated in the overhead view at right. Which of the indicated paths (A-E) would most likely correspond to the path of the crate as they pull it along?



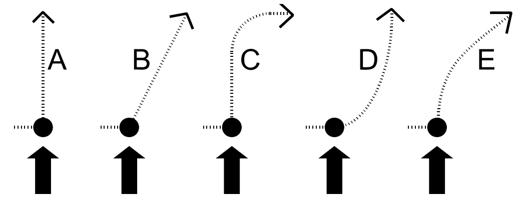
_____ 5. A stone falling from the roof of a single story building to the earth...
A) soon reaches maximum speed and then falls at a constant speed.
B) speeds up as it falls, primarily because the closer it gets to earth, the stronger the gravitational pull.
C) speeds up because of the constant gravitational 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.

_____ 6. 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?
A) $d_{heavy} = d_{light}$ B) $d_{heavy} = 2d_{light}$ C) $d_{light} = 2d_{heavy}$ D) $d_{heavy} = d_{light}\sqrt{2}$

Use the statement and diagram below to answer questions 7-10:
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.



_____ 7. Along which of the paths at below right will the hockey puck move after receiving the "kick"?



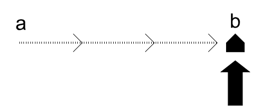
_____ 8. What is the speed of the puck just after it receives the "kick"?
A) same as v_i
B) equal to the speed from the kick (v_{kick}), and independent of the initial speed v_i
C) equal to the arithmetic sum of speeds v_i and v_{kick}
D) smaller than either v_i or v_{kick}
E) greater than either v_i or v_{kick}, but smaller than their arithmetic sum

_____ 9. Along the frictionless path you have chosen, how does the speed of the puck vary after 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

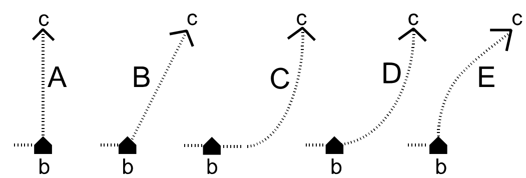
_____ 10. The main forces acting after the "kick" on the puck along the path you have chosen are:
A) downward force due to gravity
B) downward force of gravity and horizontal force of momentum in the direction of motion
C) downward force of gravity, upward force from surface, and a horizontal force in the direction of motion
D) downward force of gravity and upward force from surface
E) there are no forces acting after the kick

_____ 11. An astronaut on the moon tosses a tool toward a crater at a 20° angle above the horizontal. At what other angle could the astronaut toss the tool with the same speed and still hit the crater?
A) 80° B) 70° C) 60° D) 50° E) 40°

Use the statement and diagram below to answer questions 12-15:
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".

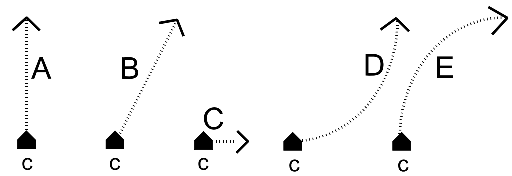


_____ 12. Along which of the paths at below right will the rocket move between "b" and "c"?



_____ 13. As the rocket moves from "b" to "c", its speed is...
A) constant
B) continuously increasing
C) continuously decreasing
D) increasing for awhile and constant later
E) constant for awhile and decreasing later

_____ 14. At "c" the rocket's engine is turned off. Which of the paths at right will the rocket follow beyond "c"?



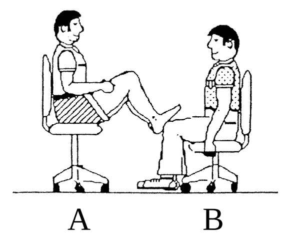
_____ 15. Beyond "c", the speed of the rocket is:
A) constant
B) continuously increasing
C) continuously decreasing
D) increasing for awhile and constant later
E) constant for awhile and decreasing later

_____ 16. 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

_____ 17. 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.

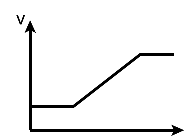
_____ 18. If the force being applied to the box in question 17 is suddenly discontinued, the box will...
A) stop immediately.
B) continue at a constant speed for a very short time and then slow to a stop.
C) immediately start slowing to a stop.
D) continue at a constant speed.
E) increase its speed for a very short time, then start slowing to a stop.

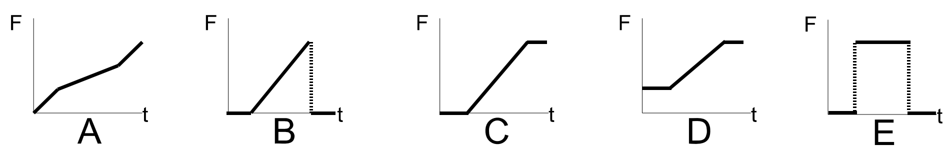
_____ 19. Two students, student "A" who masses 95 kg and student "B" who masses 77 kg, sit in identical office chairs facing each other. Student "A" places his bare feet on student "B"'s knees, as shown. Student "A" then suddenly pushes outward with his feet, causing both chairs to move. In this situation...
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.



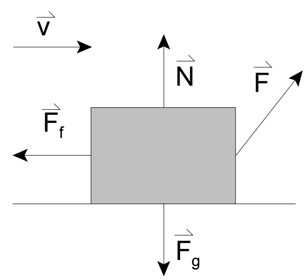
_____ 20. In the situation from question 19...
A) each student accelerates an equal amount in opposing directions.
B) student "A" accelerates more than student "B".
C) student "B" accelerates more than student "A".
D) neither student accelerates.
E) student "A" accelerates, but student "B" doesn't.

_____ 21. 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?

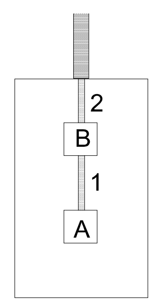




_____ 22. A person pulls a block across a rough horizontal surface at a constant speed by applying a force **F** as shown in the diagram, where the arrows correctly show the directions but not necessarily the magnitudes of the various forces acting on the block. Which of the following relations among the force magnitudes F_g , F_f , N, and F must be true?
A) $F = F_f$ and $N = F_g$
B) $F = F_f$ and $N > F_g$
C) $F > F_f$ and $N < F_g$
D) $F > F_f$ and $N = F_g$
E) none of the above



Questions 23 and 24 refer to the diagram at right.
Blocks A and B, each massing 1 kg, are hung from the ceiling of an elevator by ropes 1 and 2, which each have a negligible mass.



_____ 23. What is the force exerted by rope 1 on block A when the elevator is traveling upward at a constant speed of 2.0 m/s?
A) 2 N B) 10 N C) 12 N D) 20 N E) 22 N

_____ 24. What is the force exerted by rope 1 on block B when the elevator is stationary?
A) 2 N B) 10 N C) 12 N D) 20 N E) 22 N

_____ 25. When a block is sliding down an incline at constant speed with no applied forces, what does F_f equal?
A) $F_{g\parallel}$ B) $F_{g\perp}$ C) N D) F_g E) none of the above

_____ 26. Which statement is correct for an object pulled only by a horizontal force T across a level surface at constant velocity, if the maximum static frictional force is $F_{f\,S}$ and the sliding frictional force is $F_{f\,K}$?
A) $F_{f\,K} < T$ B) $F_{f\,S} = T$ C) $F_{f\,S} < T$ D) $F_{f\,S} > T$ E) none of the above

_____ 27. An object will accelerate only if...
A) all internal forces are balanced.
B) all external forces sum to zero.
C) internal and external forces cancel each other out.
D) the action forces are not equal and opposite to the reaction forces.
E) there are external unbalanced forces.

_____ 28. A bullet is fired horizontally from a height of 78.4 m and hits the ground 1500 m away. With what speed does the bullet leave the gun?
A) 0 m/s B) 39.2 m/s C) 153 m/s D) 375 m/s E) 1540 m/s

_____ 29. Phyllis Physics was travelling eastward in her airplane with an airspeed of 500 km/h. A 90.0 km/h wind was blowing southward against her plane. What was the ground velocity of her plane?
A) 508 km/h at 10.2° S of E
B) 508 km/h at 10.2° E of S
C) 590 km/h at 10.2° S of E
D) 590 km/h at 10.2° E of S
E) 410 km/h southeast

_____ 30. An object is pulled across a rough surface by a force T applied at an angle θ above the horizontal. If θ increases, the frictional force is...
A) increased because the weight is enlarged.
B) increased because the normal force is enlarged.
C) decreased because the weight is reduced.
D) decreased because the normal force is reduced.
E) unchanged.

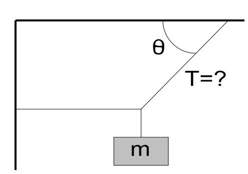
_____ 31. Velma Vector gunned her 11,500 N car from rest to a speed of 30.0 m/s over a distance of 275 m. What was the accelerating force of her vehicle?
A) 1,920 N B) 3,840 N C) 9,580 N D) 11,500 N E) 18,800 N

_____ 32. A mass *m* is suspended by three ropes as shown at right. What is the size of the tension in the diagonal rope in terms of m?
A) mg / (sin θ) B) mg (sin θ) C) mg / (cos θ) D) mg (cos θ)

_____ 33. A rocket with a mass of 1000 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?
A) 1,000 N B) 5,000 N C) 14,800 N
D) 34,200 N E) 49,000 N

Answers with Analyses

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



2. **A** Since the acceleration changes at t = 2 s, and our equations assume acceleration is constant, we must split our analysis up into two parts:

For 0 to 2 seconds: $d = \bar{v}t = \left(\dfrac{v_i + v_f}{2}\right)t = \left(\dfrac{1\,\text{m/s} + 3\,\text{m/s}}{2}\right)2\,\text{s} = 4\,\text{m}$

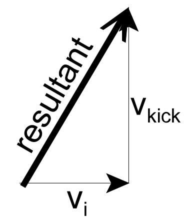
For 2 to 6 seconds: $d = \bar{v}t = \left(\dfrac{v_i + v_f}{2}\right)t = \left(\dfrac{3\,\text{m/s} + 5\,\text{m/s}}{2}\right)4\,\text{s} = 16\,\text{m}$ So the total distance traveled is 20 m.

3. **A** Average speed is distance over time; using answer #2, we find 20 m over 6 s = 3.3 m/s.

4. **B** This is a vector addition. The man's vector components are east and north, the boy's east and south. The net x-component is east. The net y-component is north since the man is stronger than the boy. (Answer A is aligned with the man's force, improperly ignoring the boy's effect.)

5. **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.

6. **A** Neither ball accelerates much horizontally and both accelerate downward at the same rate. The differing mass has no big effect, because the horizontal motion only has a small air resistance effect and vertical free-fall motion is the same for all objects.



7. **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).

8. **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.

9. **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.

10. **D** A free-body diagram could help here. 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.

11. **B** Complementary angles will yield the same range; 90° - 20° = 70°.

12. **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.

13. **B** A continuous 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.

14. **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.

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

16. **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.

17. **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.

18. **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.

19. **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 is strange; D errs by implying larger masses cause larger forces.

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

21. **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.

22. **C** The total horizontal force is zero, so part of F (its x-component) must equal friction; thus F itself must be bigger than F_f. Part of F (its y-component) is helping to support the box, reducing the normal force. Answer A ignores the fact that F is angled and not horizontal; B ignores that F is not entirely horizontal and then has it acting the wrong way vertically; D ignores the effect of F's y-component.

23. **B** Constant speed means balanced forces, so rope 1 is balancing block A's 10 N weight. Answer A confuses acceleration and velocity and ignores weight of block A; C confuses acceleration and velocity; D assumes rope 1 is helping support both blocks when in fact it only supports block A; E is like D and confuses vel. and accel.

24. **B** Rope 1 holds up block A and transmits this pull to block B.

25. **A** In this situation, all forces are balanced, so in the parallel plane $F_f = F_{g\parallel}$ while in the perpendicular plane $N = F_{g\perp}$.

26. **D** The object is sliding but not accelerating, so $F_{f\,K} = T$, but that is not given as an option. Since $F_{f\,S} > F_{f\,K}$ then $F_{f\,S} > T$. Answers A, B, and C would each make the block accelerate forward since in them $T > F_{f\,K}$.

27. **E** Only external unbalanced forces cause acceleration. Answer A deal with internal forces, which cannot change an object's linear acceleration. Answer B fails to recognize that $\Sigma\mathbf{F}=m\mathbf{a}$ means that if $\Sigma\mathbf{F}=0$ then $\mathbf{a}=0$. Answer C false assumes external forces can interact with internal forces. Answer D fails to note that, by definition, actions are always equal and opposite to reactions; also an action and its associated reaction never cancel because they never act on the same object.

28. **D**

$$v_h = \frac{d_h}{t} = \frac{1500\,\text{m}}{4\,\text{s}} = 375\,\text{m/s}$$

$$t = \sqrt{\frac{2d_v}{a_v}} = \sqrt{\frac{2(-78.4\,\text{m})}{-9.8\ \text{m/s}^2}} = 4\,\text{s}$$

29. **A**

$$|\vec{v}| = \sqrt{(500\,\text{km/h})^2 + (90\,\text{km/h})^2} = 508\,\text{km/h}$$

$$\theta = \arctan(90/500) = 10.2°\,\text{S of E}$$

30. **D** Pulling at a higher angle increases the vertical component of the tension, reducing the normal force, which in turn reduces the amount of friction. Answers A and C incorrectly show weight changing, but it is constant. Answer B has the normal force increasing, but the surface actually pushes less hard as the angle of the applied pull increases, since that pull now helps balance more of the weight. Answer E ignores the effect of the changed pull on the normal force and friction.

31. **A** $a = (v_f^2 - v_i^2) / 2d = (30\text{ m/s}^2) / (2*275\text{ m}) = 1.6364\text{ m/s}^2$

$F = ma = (W/g)\,a = (11500\text{ N} / 9.8\text{ m/s}^2)\,(1.6364\text{ m/s}^2) = 1920\text{ N}$

32. **A** The vertical part of the tension balances the weight, so $T(\sin\theta) = mg$ so $T = mg / (\sin\theta)$

33. **C** $\vec{T} = -\vec{W} + m\vec{a} = -(1000kg)(-9.8\,m/s^2) + (1000kg)(+5\,m/s^2) = 14{,}800\,N$

AP PHYSICS B - First Semester Review

Name______________________________

NUMERICAL PRACTICE PROBLEMS

The answers are in the box below; the final is entirely multiple choice but does include numerical problems.

FALLING BODIES

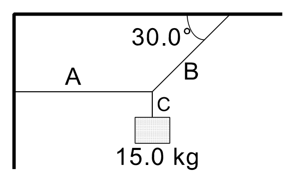
1. A ballast bag is "dropped" from a balloon that is 300 m above the ground and **rising** at 13.0 m/s.
   a) Find the maximum height the bag will reach.
   b) Find the bag's height above the ground 5.00 seconds after it is released.
   c) Find the time it will take for the bag to strike the ground.

PROJECTILES

2. Vainly attempting to catch the roadrunner, Wile E. Coyote fires himself from a cannon at an upward angle of 35.0° to the horizontal. His total initial speed is 300 m/s. He lands in a canyon, 20.0 m below the level of his cannon. How far did he travel horizontally?

3. A projectile is fired from atop a vertical 200 meter cliff above a flat valley. Its initial velocity is 60.0 m/s at 60.0° above the horizontal. What is the horizontal distance from the cliff base to the impact site?

NEWTON'S LAWS WITHOUT FRICTION COEFFICIENTS

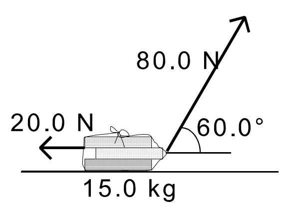


4. A 15.0 kg mass is suspended by three ropes as shown in the diagram. What force is exerted by rope B?

5. A package weighing 50.0 N was towed up a smooth 35.0° ramp at a constant velocity.
   a) What was the tension in the tow rope?
   b) What was the magnitude of the normal force the ramp exerted?
   c) If the tow rope broke, what would be the acceleration **down** the slope?

6. Victor Velocity placed a 20.0 kg bundle of physics books on an inclined plane that was angled up from the ground at 45.0°. If the frictional force between the books and the plane was 10.0 N, what was the acceleration of the tumbling tomes?

7. Victor Velocity was dragging his usual 15.0 kg bundle of books with a rope as shown in the diagram. If the rope was angled at 60.0° to the horizontal and had a tension of 80.0 N, and the friction between the books and floor was 20.0 N, what was the acceleration?



8. A 2.005 kg block of wood moving at 0.374 m/s slides 270 cm along a tabletop before stopping. What is the frictional force between the block and the table?

Answers:

1. a) 309 m
   b) 243 m
   c) 9.26 s
2. 8,660 m
3. 408 m
4. 294 N
5. a) 28.7 N
   b) 41.0 N
   c) 5.63 m/s^2
6. 6.43 m/s^2
7. 1.33 m/s^2
8. 0.0519 N