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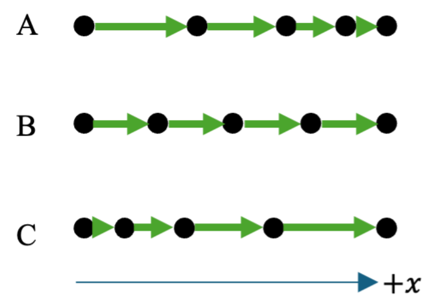
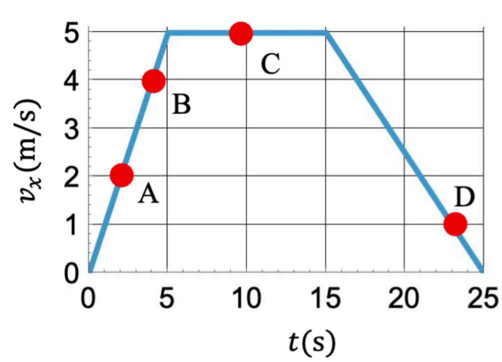
I. **Multiple Choice** [5 pts each] Bubble in the most correct answer on your bubble sheet and circle the correct answer here.

1. [5 pts] The motion diagrams shown at right are for three objects. For which object(s) is the acceleration pointing to the left in the time interval shown?
   A. A only.
   B. B only.
   C. C only.
   D. A and B but not C.
   E. A and C but not B.



2. [5 pts] An airplane travels from city A to city B, a distance of 150 miles to the east of city A in half an hour. Then it travels from city B to city C, which is 400 miles to the west of A in 1.2 hours. Calculate the magnitude of the plane's average velocity during the entire trip $v_{avg,\, A\rightarrow B\rightarrow C}$
   A. 50 mile/hour
   B. 150 mile/hour
   C. 240 mile/hour
   D. 320 mile/hour
   E. 450 mile/hour

Use the following situation to answer the next two questions:
The graph at right shows the plot of the velocity vs. time for a runner moving along the *x*-axis.



3. [5 pts] What is the total distance they ran?
   A. 130 m
   B. 62 m
   C. 54 m
   D. 88 m
   E. 72 m

4. [5 pts] Rank the <u>**magnitudes**</u> of the runner's acceleration at points A, B, C and D.
   A. $a_A < a_B < a_C < a_D$
   B. $a_D < a_A < a_B < a_C$
   C. $a_D < a_C < a_A = a_B$
   D. $a_C < a_D < a_A = a_B$
   E. $a_C < a_A = a_B < a_D$

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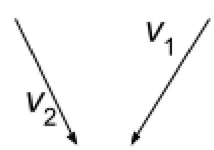
Use the following situation to answer the next two questions:

You flip a coin straight up. The coin spends in air 0.75 s in total before you catch it. In what follows, neglect air resistance.

5. [5 pts] At what initial speed was the coin launched?
   A. 5.2 m/s
   B. 3.7 m/s
   C. 1.6 m/s
   D. 4.8 m/s
   E. Information provided is not enough to answer.

6. [5 pts] As the coin is rising to half the maximum height above the launch point, does it need more time, less time, or the same amount of time to travel the remaining half of the distance to the top?
   A. More time.
   B. Less time.
   C. Same amount of time.
   D. The answer depends on the initial speed.
   E. Information is not enough to answer.

7. [5 pts] At an initial time $t = t_1$ an object has velocity $\vec{v}_1$. Later on at time $t = t_2$, the object's velocity is $\vec{v}_2$. The two vectors are shown at right. Which of the following arrows best describes the general direction of the average acceleration experienced by the object?
   A. ↘
   B. ↖
   C. ↙
   D. ↗
   E. →



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8. [5 pts] Two projectiles A and B, are launched with the same initial speed v_i at the same height *h* but at different launch angles. Projectile A is at an angle θ_A above the horizontal, and θ_B is equal to θ_A but below the horizontal. Which one of the following statements is true, assuming no air resistance?
   A. Just before reaching the ground A has greater speed than B.
   B. Just before reaching the ground B has greater speed than A.
   C. The two projectiles have the same speed just before reaching the ground.
   D. This cannot be determined from the information above.
   E. None of the above is true.

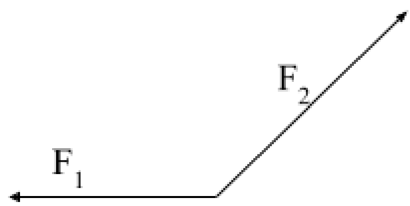
9. [5 pts] A bucket is at rest on the floor of a truck. All of a sudden, the bucket slides towards the front of the truck. According to Newton's first law, which of the following statements could describe the motion of the bus? Neglect friction and assume the bus is moving on a horizontal road.
   I. The truck was initially at rest and then accelerated forward.
   II. The truck was already moving forward at constant speed and then sped up
   III. The truck was already moving in reverse at constant speed and then sped up..
   A. (I) only.
   B. (II) only.
   C. (III) only.
   D. (I) and (II).
   E. (I), (II) and (III).

10. [5 pts] A person jumps from a cliff into the water and they are in free fall. Ignore air resistance. When they are freely falling what is the force the person applies to the earth?
   A. 0 N, since they are in free-fall they apply no force to the earth.
   B. The force on the earth from the person is the same magnitude as the weight of the person, due to Newton's 3rd law.
   C. The earth's mass is so large it is a tiny value compared to the weight of the person. You can find it via the ratio of the masses of the person and the earth.
   D. It depends on the acceleration of the person, due to Newton's 2nd law. If (and only if) they accelerate at $a = -g$ then they are equal and opposite.
   E. None of these are correct.

11. [5 pts] On a very slippery surface you hit two balls initially at rest with a hammer, which makes them slide across the surface. You apply the exact same force to both. Ignoring air resistance and friction, which of the following is true?
    A. The ball moving the fastest has the highest mass.
    B. The ball moving the fastest has the lowest mass.
    C. Regardless of the mass, both balls should have the same final speed since they were hit with the same force.
    D. A. and B. are true
    E. None of these are true.

12. [5 pts] Two forces act on a body as shown, what is the direction of the net force on the body?

    A. ↑
    B. ↓
    C. ↙
    D. ←
    E. →



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II. **Lecture Free Response** [20 pts total]: Show work and/or explain reasoning where indicated.

For problems 13-16 the following situation applies:
A hockey puck is hit very hard and flies off of a ramp. The ramp makes an angle of 25 degrees above the horizontal. There is no air resistance.

13. [2 pts] After the hockey puck leaves the ramp, what is its acceleration? Give both magnitude and direction.

Direction:	Magnitude:
Down, or towards the ground or arrow down, etc	9.8 m/s/s or g

14. [7 pts] If the hockey puck started with a velocity of 20.0 m/s, what is the magnitude of the velocity at the highest point? *Show work or explain reasoning* for full credit.

Since the velocity in the y-direction is zero at the highest point, the only velocity component is the x-direction. This is constant since we choose the acceleration to be zero in the x-direction.

$$v_{max} = v_{ox} = v_0 \cos\theta$$

v = 18 m/s

15. [5 pts] How long does it take to get to the highest point? *Show work* or *explain reasoning* for full credit.

Now we will use the y-direction, understanding that velocity at the highest point is zero in this direction.

$$v_{fy} = v_{oy} - gt$$

$$t = \frac{v_{oy}}{g} = \frac{v_o \sin\theta}{g}$$

t = 0.86 s

16. [6 pts] What is the horizontal displacement of the puck at its highest point after leaving the ramp? *Show work* or *explain reasoning* for full credit.

Since we have t from above, we can use this in the x-direction with the constant velocity.

$$x_f = x_o + v_{ox}t + 1/2\, a_x t^2$$

$$x_f = v_{ox}t = v_o \cos\theta\, t$$

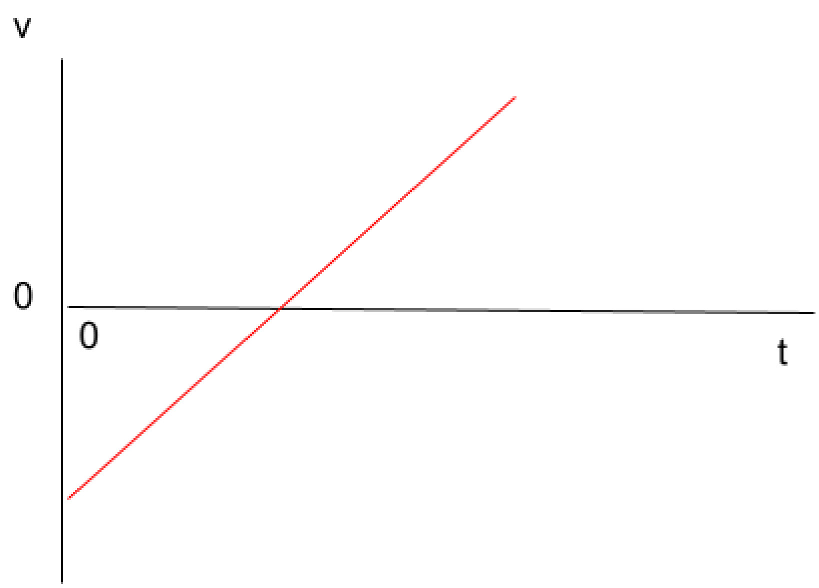
x = 15.5 m

III. **Tutorial Free Response** [20 pts total]: Problems 17-20. Show work and/or explain reasoning where indicated.

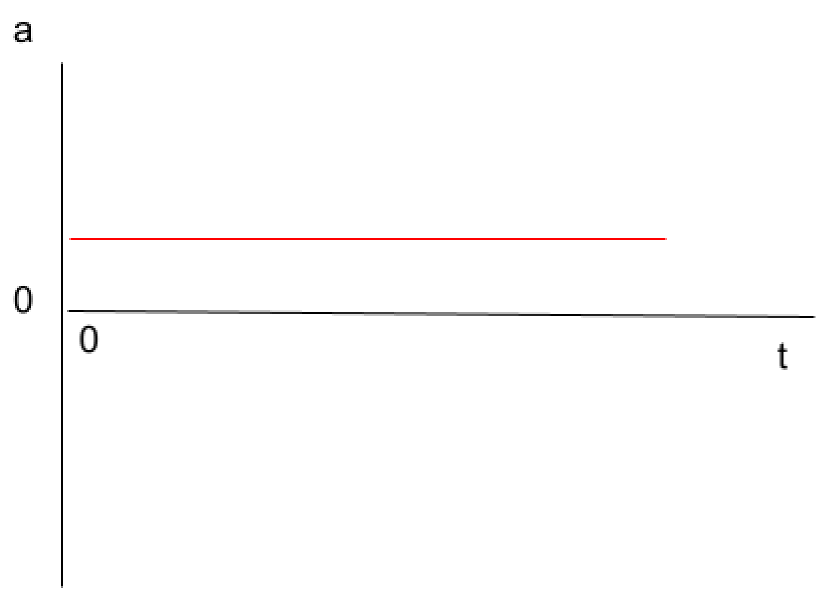
For 17. and 18., the following situation applies: you are moving towards a motion detector, and *slowing down*. You eventually turn around and speed up.

Assume away from the detector is the positive direction.

17. [5 pts] Draw the velocity vs time graph below for this motion.



18. [5 pts] Draw the acceleration vs time graph for this motion.



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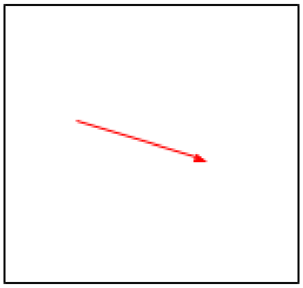
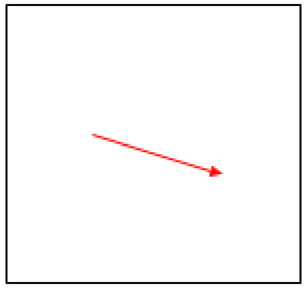
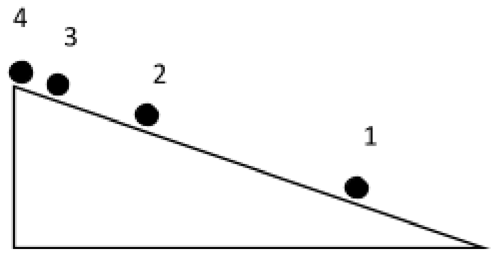
19. [5 pts] The diagram at right shows the motion diagram for a ball moving up a ramp. In the box below, draw the direction of the change in velocity between 3 and 4, that is Δv_{34}. In the next box draw the direction of the acceleration between 3 and 4, a_{34}. If it is zero state that explicitly. *Explain* your reasoning.

Δv_{34}



a_{34}



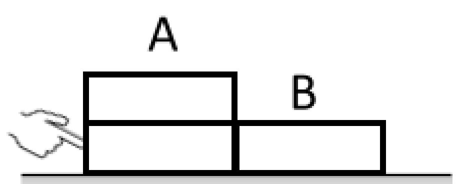


We see that the ball is slowing down, thus the velocity vector at 3 is longer than at 4, which is zero. So the change in velocity must be down the ramp.

The acceleration is always in the same direction as the change in velocity. The time interval is not given so we can't know if they have equal magnitudes, which isn't relevant here.

20. [5 pts] A set of three identical blocks are pushed as seen in the diagram below. There is friction between the ground and the blocks, and between the blocks. The system moves to the right at a *constant speed*.

Is the force of friction on block A *greater than, less than, or equal to* the force from the hand? *Explain* your answer for full credit.



$f_{TA} < n_{HA}$

The normal force from the hand must be greater. If we look at the net force on A it includes the normal force from B. Thus from Newton's second law:

$$n_{HA} - f_{TA} - n_{BA} = 0$$

Since the object is moving at a constant speed $a = 0$. We immediately see that

$$n_{HA} = f_{TA} + n_{BA}$$