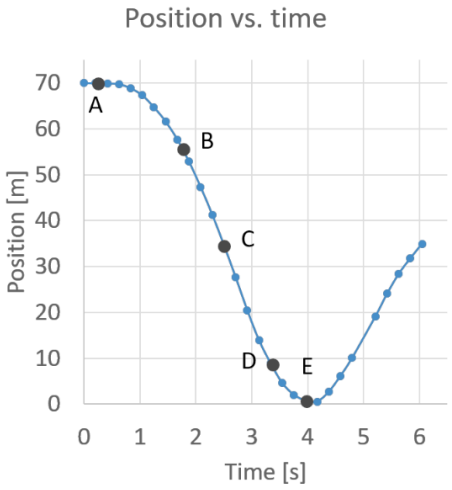
Section I: Lecture and Lab Multiple Choice (12 questions, 5 points each)

Use the following scenario for the next two questions.

The figure at right shows the position versus time graph for a bungee jumper.

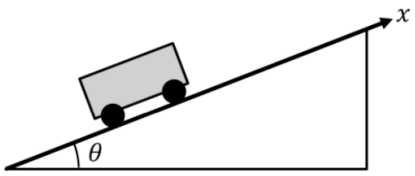


1. (5 points) At which instant, marked by letters A through E, does the velocity vector of the jumper point in the opposite direction from the acceleration vector of the jumper?

2. (5 points) Estimate the average velocity of the jumper between 2 s and 5 s.
   A) -5 m/s
   B) -12 m/s
   C) -22 m/s
   D) 12 m/s
   E) 22 m/s

Use the following scenario for the next three questions.

A cart moves on an inclined track with negligible friction. The position of the cart, x, measured from the bottom of the incline up along the track surface as a function of time t is given by $x(t) = (-2.8\ \text{m/s}^2)t^2 + (3.2\ \text{m/s})t + 0.50\ \text{m}$.



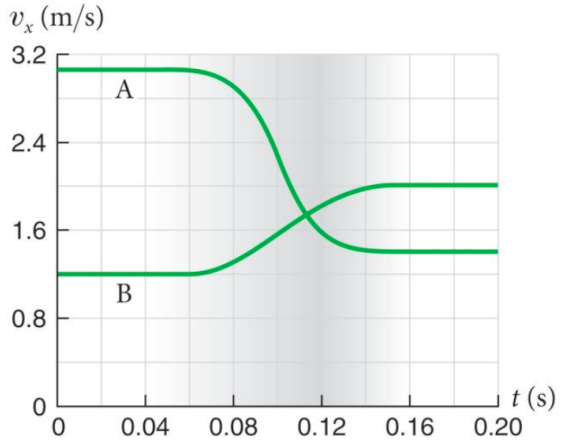
3. (5 points) Which of the following statements best describes the motion of the cart starting at $t = 0$ s?
   A) The cart starts at rest and moves down the incline with increasing speed.
   B) The cart initially moving downward keeps moving downward with increasing speed.
   C) The cart is initially moving upward at the bottom of the incline ($x(0) = 0$ m), slows down, turns around, and moves downward with increasing speed.
   D) The cart is initially moving upward above the bottom of the incline ($x(0) > 0$ m), slows down, turns around, and moves downward with increasing speed.
   E) Not enough information is given to determine.

4. (5 points) What is the maximum value of x that the cart has in this motion?
   A) 1.4 m
   B) 0.50 m
   C) 1.6 m
   D) 0.90 m
   E) 6.5 m

5. (5 points) What is the angle of incline from the horizontal of this track, θ?
   A) 0.61°
   B) 8.2°
   C) 17°
   D) 35°
   E) 55°

Use the following situation for the next three problems.

Two carts A and B move on a level track with negligible friction. The figure below shows the velocities of the carts as a function of time during their interaction. The inertia of cart A is 1.5 kg.



6. (5 points) Which of the following statements describes the type of interaction represented?
   A) This is an elastic collision.
   B) This is an inelastic collision (but not totally inelastic).
   C) This is totally inelastic collision
   D) This is an explosive separation.
   E) Not enough information is given.

7. (5 points) Compare the magnitudes of the changes in momenta of cart A and B during this interaction.
   A) The magnitude of change in momentum of cart A is greater than that of cart B.
   B) The magnitude of change in momentum of cart A is less than that of cart B.
   C) The magnitude of change in momentum of cart A is equal to that of cart B.
   D) Not enough information is given to determine.

8. (5 points) What is the change in kinetic energy of cart B due to this interaction?
   A) 4.1 J
   B) 0.90 J
   C) 1.0 J
   D) 5.7 J
   E) 1.9 J

9. (5 points) A 20-kg child is sliding on an icy surface toward her mother at 3.0 m/s. Her 68-kg mother starts toward her at 2.0 m/s, intending to catch her. Determine the convertible kinetic energy.
   A) 190 J
   B) 7.7 J
   C) 110 J
   D) 85 J
   E) 250 J

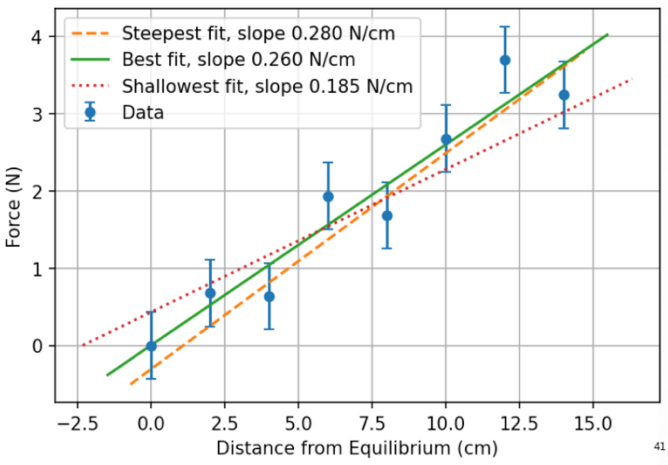
10. [5 pts] A student is analyzing the motion of an object in a video using a ruler and a stopwatch. The student's data are shown in the table at right.

Time (s)	Position (cm)
0.00	12.0
1.00	8.0
2.00	4.2
3.00	0.6
4.00	-2.8

Which of the following models for the object's motion is the best description given this data?

A. Motion with constant acceleration in which the object is speeding up
B. Motion with constant acceleration in which the object is slowing down
C. Motion with constant velocity
D. Some other kind of accelerated motion in which the object is speeding up
E. Some other kind of accelerated motion in which the object is slowing down

11. [5 pts] A student hangs several objects from a spring, and measures how far the spring stretches. They plot their data as shown.

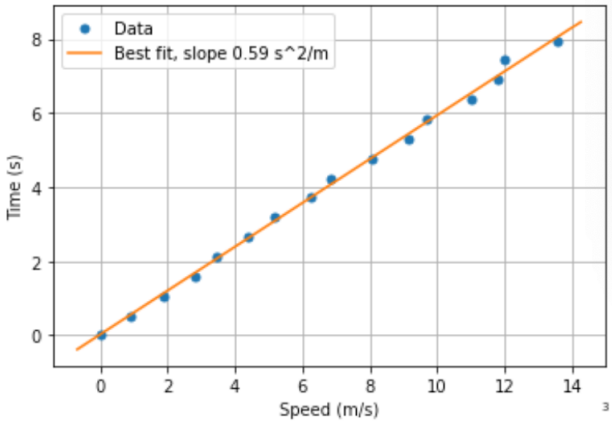


Which of the following is the best estimate for the slope of the best fit line?

A. 0.26 ± 0.08 N/cm
B. 0.3 ± 0.08 N/cm
C. 0.3 ± 0.1 N/cm
D. 0.26 ± 0.04 N/cm
E. 0.260 ± 0.038 N/cm

12. [5 pts] A student is investigating the relationship between time elapsed and how fast an object is moving.

They produce the graph of ***time*** versus ***speed*** at right. The slope of the best-fit line is 0.59 ± 0.01 s^2/m.



Which of the following best describes the meaning of the number 0.59?

A. The number 0.59 means that on average, the object is moving 0.59 times faster each second.

B. The number 0.59 means that on average, the object accelerates by 0.59 m/s each second.

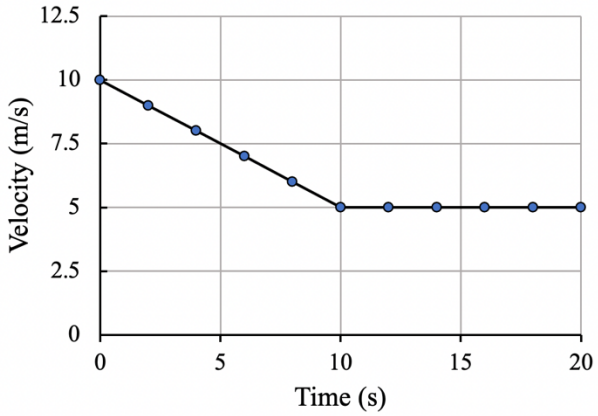
C. The number 0.59 means that on average, for each 1 m/s change in the speed of the object, 0.59 seconds elapse.

D. The number 0.59 means that on average, the speed of the object doubles every 0.59 seconds.

E. None of the above.

Section II: Lecture Free Response (20 pts)

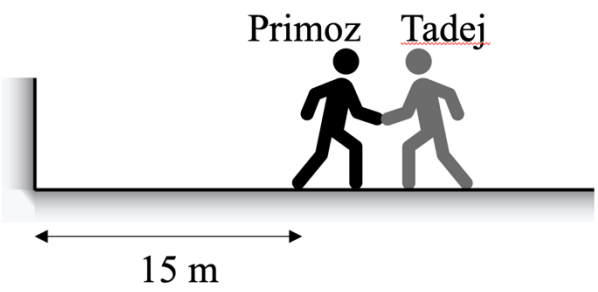
13. [5 pts] The graph at right shows the velocity of a car for a 20-s time interval. At $t = 0$ s, the car is positioned at $x = 25.0$ m. Determine the position of the car at $t = 20.0$ s. Show your work.



14. [5 pts] At $t = 0$ s, two blocks, A and B are moving with the same speed on a horizontal track. Block A is located a distance x behind block B. The blocks then descend down an incline and then back onto a horizontal track (all surfaces are frictionless).

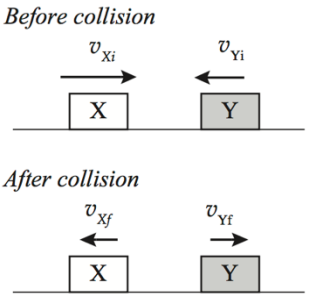
When both blocks are on the lower horizontal track, will the distance between the blocks be *greater than, less than,* or *equal to x*? Explain your reasoning.

15. [5 pts] Primoz (72 kg) and Tadej (65 kg) are standing at rest on a frictionless ice rink. Primoz pushes on Tadej, which results in Tadej moving to the right with a speed of 1.60 m/s. If Primoz is initially 15.0 m from the wall of the ice rink, how long will it take Primoz to reach the wall? (Primoz only moves as a result of pushing on Tadej.) Show your work.



16. [6 pts] Two gliders, X and Y, of mass m_X and m_Y respectively, are involved in a collision on a frictionless track. The mass of glider X is less than that of glider Y. The initial speed of glider X is greater than that of glider Y. After the collision, gliders X and Y move in opposite directions with the same final speed.

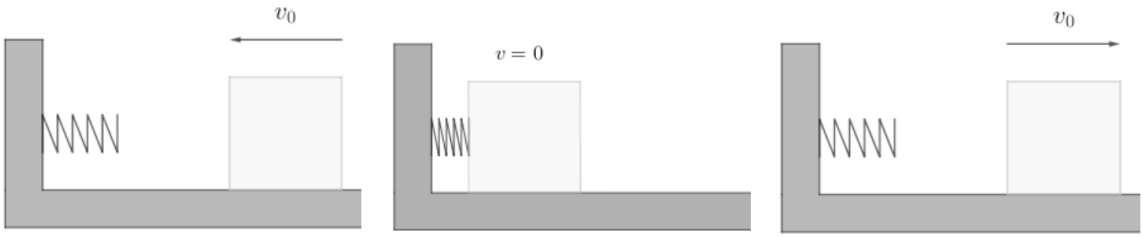
Is the magnitude of the glider X's initial momentum, *greater than, less than,* or *equal to* glider Y's initial momentum? Explain your reasoning.



Section III: Tutorial Free Response (20 pts)

A block slides to the left along a frictionless surface (Fig. 1) until it comes into contact with a spring connected to a wall. The wall and flat surface are fixed. The block slows, reaches zero velocity for an instant (Fig. 2), and then immediately starts speeding up in a direction opposite to its initial velocity. By the end of the interaction with the spring, it is moving at its initial speed (Fig. 3).

Fig 1. **Fig 2.** **Fig 3.**



17. [8 pts] The total amount of time that the block is in contact with the spring is Δt. What is the average acceleration of the block during this time (both magnitude and direction). Explain.

18. [5 pts] Does the momentum of the block remain constant during the collision with the spring? Yes, or no? Explain.

19. [2 pts] Is the system consisting of only the block an isolated system? Explain.

20. [5 pts] A cart moves to the right across a horizontal track. The track is frictionless except for a small portion which is rough. A motion diagram for the cart is shown below.

In the space at right, a vector for the velocity of the cart at t_2 is shown. Draw a quantitatively correct velocity vector at t_9, and draw a vector to represent the change in velocity of the cart between t_2 and t_9. Explain.