Name:_____ ID: _____

Physics 201

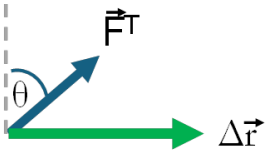
Final Exam

12/8/2025

Collaboration is not allowed. Allowed on your desk are: ten 8.5 x 11 inch doubled-sided sheets of notes that are bound together, non-communicating graphing scientific calculator, a page of scratch paper, writing utensils, and the exam. You will have 110 minutes to complete this exam.

For questions 1 through 7, **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **16** correct answers in this section and **only the first 16 filled in answers will be graded**. There is no partial credit.

1. You pull your sled with a rope that has a force of tension $\vec{F}^{T}$ through a displacement of $\Delta\vec{r}$. For which angle θ, represented in the figure, will you have done the most work on the sled?



□ (a) 34°
□ (b) 44°
□ (c) 45°
□ (d) 64°
□ (e) 72°

2. For the situation in the previous question, if the sled maintains a constant speed during the time depicted in the diagram, which of the following statements are true. Note: there may be other forces acting on the sled which are not depicted in the vector operation diagram in the previous question.

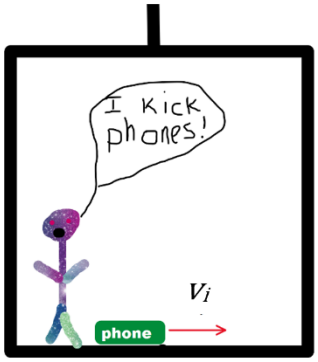
□ (a) The sled has negative work being done on it overall.
□ (b) The sled has just as much positive work being done on it as negative work.
□ (c) The kinetic energy of the sled is increasing.
□ (d) The kinetic energy of the sled is constant.
□ (e) The momentum of the sled is increasing.
□ (f) The net impulse acting on the sled is a constant non-zero value.
□ (g) The net impulse acting on the sled is zero.

3. Which of the following statements are true.

□ (a) The **momentum** of a system is **always** conserved.
□ (b) The **momentum** of a system is **sometimes** conserved.
□ (c) The **momentum** of a system is **never** conserved.

□ (d) The **total energy** of a system is **always** conserved.
□ (e) The **total energy** of a system is **sometimes** conserved.
□ (f) The **total energy** of a system is **never** conserved.

4. Consider the question from the 2nd midterm where an elevator is travelling upwards and slowing down. A phone is kicked across the floor of the elevator so that it is given an initial speed, $\mathbf{v_i}$, to the right. Eventually, due to friction between the phone and the elevator, the phone comes to rest in a time **Δt**.



□ (a) If the coefficient of friction increases Δt will **increase**.
□ (b) If the coefficient of friction increases Δt will **decrease**.
□ (c) If the coefficient of friction increases Δt will **stay the same**.

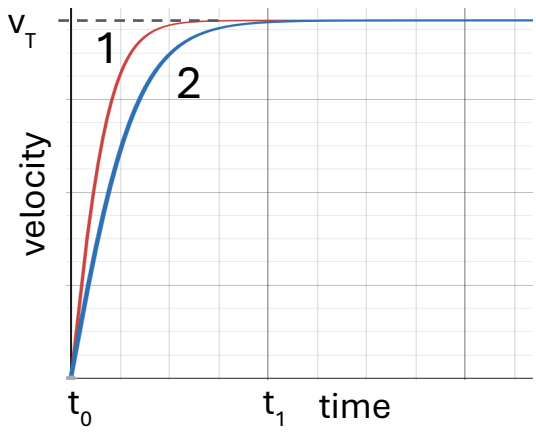
□ (d) If the magnitude of the acceleration of the elevator increases Δt will **increase**.
□ (e) If the magnitude of the acceleration of the elevator increases Δt will **decrease**.
□ (f) If the magnitude of the acceleration of the elevator increases Δt will **stay the same**.

□ (g) If the mass of the phone increases Δt will **increase**.
□ (h) If the mass of the phone increases Δt will **decrease**.
□ (i) If the mass of the phone increases Δt will **stay the same**.

5. Which of the following physical quantities point in the same direction as the change in velocity.

□ (a) change in position
□ (b) velocity
□ (c) average acceleration
□ (d) average net force
□ (e) momentum
□ (f) net impulse
□ (g) work
□ (h) kinetic energy
□ (i) speed
□ (j) distance travelled

6. Consider the plot of two skydivers coming to a terminal velocity, V_T. Terminal velocity occurs when the force of air resistance is equal to the force of gravity. Which of the following statements are true?

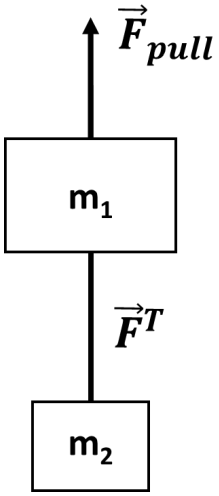


□ (a) When they reach V_T they are no longer accelerating.
□ (b) Both skydivers reach terminal velocity at the same time.
□ (c) Skydiver 1 has a larger terminal velocity than skydiver 2.
□ (d) Skydiver 1 travels a **larger distance** than skydiver 2 between t_0 and t_1.
□ (e) Skydiver 1 travels a **shorter distance** than skydiver 2 between t_0 and t_1.
□ (f) Skydiver 1 travels **the same distance** as skydiver 2 between t_0 and t_1.
□ (g) When they reach V_T they have reached their maximum acceleration.

7. Two blocks, with $\mathbf{m_1 = 2\ m_2}$ are connected by one rope and lifted upwards by another rope. A force, $\mathbf{F_{pull}}$, is applied to the top rope such that both blocks travel upwards at a constant speed.

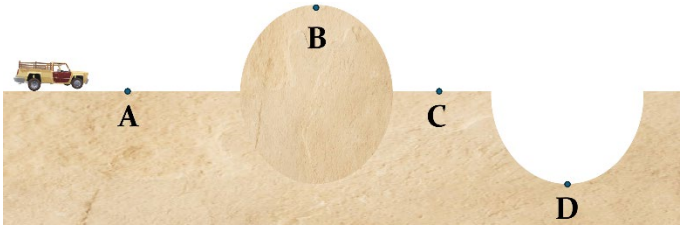
□ (a) The work done by F_{pull} is **smaller** than the work done by F^T on the bottom block.
□ (b) The work done by F_{pull} is **the same** as the work done by F^T on the bottom block.
□ (c) The work done by F_{pull} is **larger** than the work done by F^T on the bottom block.

□ (d) The magnitude of F_{pull} is **equal** to the magnitude of F^T.
□ (e) The magnitude of F_{pull} is **twice** the magnitude of F^T.
□ (f) The magnitude of F_{pull} is **three times** the magnitude of F^T.

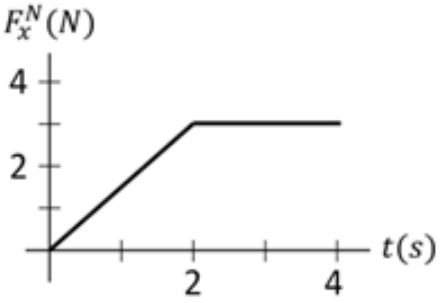


Free Response Questions

8. (4 points) You are driving at a constant speed on a golden landscape as shown in the picture below (but imagine it is a smooth path). The hill and valley are both, approximately, shaped like a circle and your tires always touch the road. At which labeled point(s) (**A, B, C, D**) is the normal force from the seat onto you **largest** and where is it **smallest**? (remember to answer both!) Explain your reasoning using a combination of words, diagrams, and/or math.



9. (4 points) You push a 2.5 kg block of ice across a flat, frictionless ice-skating rink. With the block starting at rest, you apply a normal force in a horizontal direction. This force is represented in the provided graph. After 4 seconds, what is the speed of the block? Show your work using any combination of words, diagrams, algebra, etc.



10. (8 points) You are going on an adventure. On your adventure, you notice a skateboard with a sign that says "please try out" right before an open, flat road. You are very excited and run and jump onto the skateboard right as you remember, 'I don't know how to use a skateboard!' You remember conservation of momentum and think that if you can throw your phone fast enough, you can make yourself stop. Assume your phone mass is **300 grams** and that you forgot all other ways of stopping. You estimate you are traveling at **5 m/s** in the **positive x-direction** and (for the case of this problem) the mass of you and the skateboard is **75 kg**.

    (a) What is the net initial momentum vector of a system that includes you, the skateboard, and your phone?
    (b) Sign sensemaking: Which direction should you throw your phone to slow yourself down? Explain your reasoning.
    (c) How fast would you need to throw your phone to stop you and the skateboard?

11. (8 points) Water towers, once their top is filled with water, have a lot of energy stored in the water tower, as well as water! Let's say we have a water tower that is **50 meters** tall, and it holds **7,570,823 kilograms** of water (2 million gallons!). The one pictured is decorated like a colorful hot air balloon (and is in Kansas)!

(a) How much gravitational potential energy does the water have when the tower is full of water? Assume **y = 0 m** at ground level.

(b) If someone came with a big bulldozer and knocked the tower over (sad) so all the water falls freely to the ground, how fast would the water be moving right before it hits the ground?

(c) It takes about **6 million Joules** to run a lightbulb for a day. If half the potential energy of the water can be converted to electrical energy, for how many days could it power a lightbulb?

12. (10 points) Before she remembers she can defy gravity, Elphaba is trying to rearrange her castle and is planning to move a heavy statue which has a mass of **100 kg**. The coefficient of kinetic friction between the statue and the ground is **0.4**. She wants to move the statue up a ramp that makes a **10°** angle with the horizontal. She and the statue start at rest. Then she pushes the statue up the ramp at a constant acceleration for **5 seconds** at which time it reaches a speed of **15 m/s**. The force of her push is parallel to the ramp (**10°** above the horizontal).

    (a) What is the magnitude of the acceleration of the heavy statue while Elphaba is pushing it?
    (b) Draw and label a scaled free body diagram of the statue while Elphaba is pushing.
    (c) With what magnitude of force is Elphaba pushing?