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Physics 201

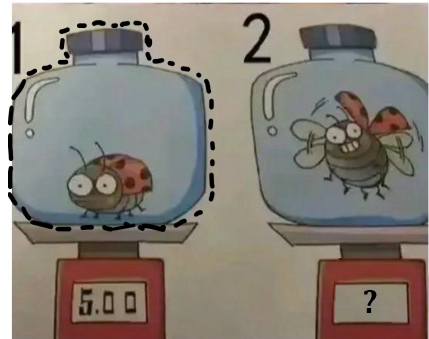
Final Exam

12/12/2023

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 6 **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 **11** correct answers in this section and only the first **11** filled in answers will be graded. There is no partial credit.

1. Consider the system contained within the dotted line that includes the glass jar, the bug, and the air inside the jar. In the first scenario the bug is at rest on the bottom of the jar and the scale measuring the normal force acting on the jar reads 5.00. In the 2nd scenario the bug is flying around in the jar, not touching the glass. Which of the following statements are true about the reading on the scale in the 2nd scenario?



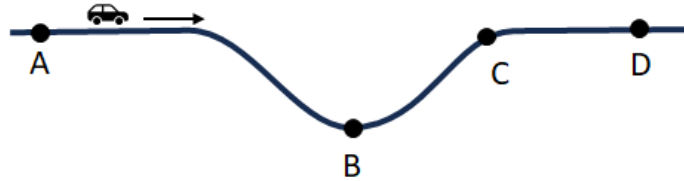
- (a) If the bug is flying **stationary** (hovering) the reading on the scale will be **less than 5.00**.
 - (b) If the bug is flying **stationary** (hovering) the reading on the scale will be **5.00**.
 - (c) If the bug is flying **stationary** (hovering) the reading on the scale will be **more than 5.00**.
 - (d) If the bug is **accelerating upwards** the reading on the scale will be **less than 5.00**.
 - (e) If the bug is **accelerating upwards** the reading on the scale will be **5.00**.
 - (f) If the bug is **accelerating upwards** the reading on the scale will be **more than 5.00**.
2. Shown here are the momentum and acceleration for several different types of motion. In which case(s) is the object speeding up?

- (a)
 - (b)
 - (c)
 - (d)
 - (e)
- (a) $\vec{p} \leftarrow \vec{a}$ (b) \vec{p} and \vec{a} in the same direction
- (c) \vec{a} and \vec{p} in opposite directions
- (d) \vec{p} and \vec{a} perpendicular
- (e) \vec{a} and \vec{p} in opposite directions

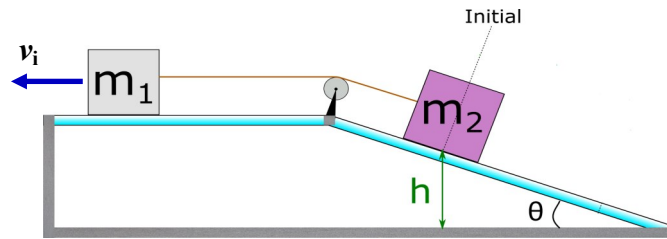
3. A $m = 4 \text{ kg}$ bag of presents falls from Santa's sleigh while he is flying horizontally above the city. As it is falling to the ground, which of the following statements are true? Ignore air resistance (drag).
- (a) The bag will have a **horizontal** acceleration magnitude **equal to zero**.
 - (b) The bag will have a **horizontal** acceleration magnitude **greater than zero but less than g**.
 - (c) The bag will have a **horizontal** acceleration magnitude **equal to g**.
 - (d) The gravitational force on the bag is 4 N.
 - (e) The gravitational force on the bag is 9.8 N.
 - (f) The gravitational force on the bag is 39.2 N.
 - (g) The bag will have a **vertical** acceleration magnitude **equal to zero**.
 - (h) The bag will have a **vertical** acceleration magnitude **greater than zero but less than g**.
 - (i) The bag will have a **vertical** acceleration magnitude **equal to g**.

4. You are driving in a car. At a given instant, you feel that the magnitude of the normal force from your seat is less than what it was when your car was stationary. In which location(s) could you be? (see image)?

- (a) A
- (b) B
- (c) C
- (d) D

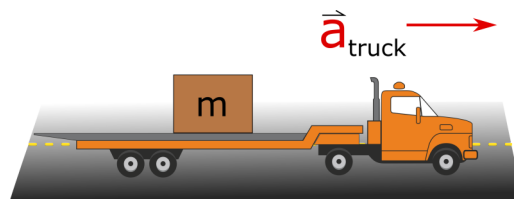


5. Two masses are connected via a taut string that goes over an ideal pulley. Mass m_1 is on a horizontal surface, and mass m_2 is on an incline. At the moment shown m_1 is traveling to the left and slowing down. There is negligible friction between the masses and the surfaces. Which of the following statements are correct for the immediate time that follows.



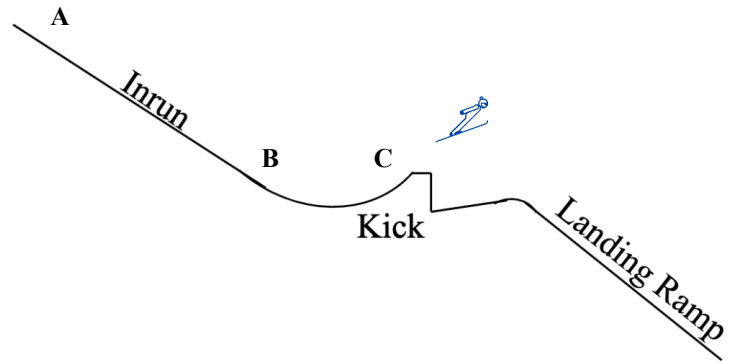
- (a) The kinetic energy of m_1 doesn't change but m_2 has gravitational potential energy increasing while its kinetic energy decreases.
- (b) The gravitational potential energy of m_1 and m_2 remains constant as the kinetic energy from m_1 is converted into kinetic energy in m_2 .
- (c) Gravitational potential energy of both m_1 and m_2 is converted into increasing the kinetic energy of m_1 and m_2 .
- (d) The kinetic energy of both m_1 and m_2 is converted into increasing the gravitational potential energy of m_2 .

6. Consider a truck that is accelerating to the right. The truck is carrying a box that is not sliding relative to the truck. Which of the following statements are true for this situation.



- (a) The truck **must** be speeding up to the right.
- (b) The truck **could either** be speeding up to the right or slowing down to the left.
- (c) The direction of friction acting on the box **must** be to the left.
- (d) The direction of friction acting on the box **could either** be to the left or the right.
- (e) The direction of friction acting on the box **must** be to the right.

7. (5 points) Consider the ski jump where people start at point **A** and slide down an incline, gaining speed and jumping off the kick at **C**. Point **B** and **C** are at the same height. Do not ignore resistive forces like friction.



- (a) Use the provided energy flow diagram to show the energy transformations and transfers if the system includes the skier, the Earth, the atmosphere, and the ski jump hill. Be sure that the arrows clearly start and stop in a specific box. If one of the energies is the same from one point to the next, show the horizontal arrow that indicates it is the same. Do not worry about the size of the dots at the arrow's tail. If there is any external work, be sure to identify which force(s) are responsible for it.
- (b) Describe in words the transformations and transfers in energy from point **A** to point **C**.

Environment		Time →		
System	A	B	C	
E^{Chem}				
KE				
U^g				
U^s				
E^{Sound}				
E^{Th}				

8. (10 points) A **10,000 kg** spaceship, far from any gravitational bodies (ignore gravity), is traveling at a constant **1000 m/s** in the positive y-direction. To avoid a potential asteroid the thrusters are turned on to a constant **98,000 N** in a direction **30 degrees** from their initial trajectory, from the positive y-direction towards the negative x-direction.
- (a) Will the ship speed up or slow down? Explain.
 - (b) What is the ship's magnitude of displacement during the first 2 minutes the thrusters are on?
 - (c) What is the ship's velocity after the first 2 minutes the thrusters are on?

9. (10 points) High energy particles can be created in particle accelerators like the Large Hadron Collider. These high energy particles are not in their natural state and they will sometimes spontaneously decay (split) into many new particles. Consider such a spontaneous decay where a particle of mass m and speed v is traveling in the positive x-direction. All of the sudden it splits into 3 particles.
- Particle 1 is traveling in the positive y-direction with speed v_1
 - Particle 2 is traveling in the negative y-direction with speed v_2
 - Particle 3 is traveling in the positive x-direction with speed v_3
 - Particle 2 is twice as massive as particle 1.
 - Particle 3 is three times as massive as particle 1.
- (a) Do you expect particle 1 to be traveling faster or slower than particle 2? Use proportional reasoning sense-making to determine which should be traveling faster.
- (b) Find the ratio v_1 / v_2 . You should be able to get a number or a fraction.
- (c) Do you expect particle 3 to be traveling faster or slower than the original high energy particle? Use proportional reasoning sense-making to determine whether it should be traveling faster or slower than the original particle's speed v .
- (d) Find the ratio v_3 / v . You should be able to get a number or a fraction.

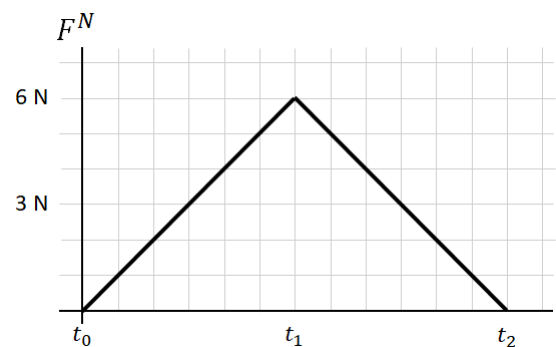
10. (9 points) A cart from your physics lab is rolled along the track at a speed of 0.65 m/s . The cart collides with a second, identical, cart, that is initially at rest. Both carts have a mass of 0.32 kg . The two carts stick together and travel at an unknown speed v_f after the collision.

(a) What is the magnitude of v_f ?

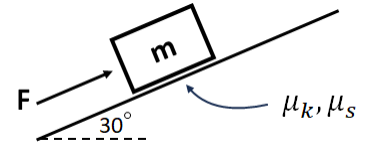
(b) What is the initial kinetic energy of the system?

(c) How much kinetic energy is converted to thermal energy during the collision?

(d) A graph of the magnitude of the force as a function of time felt by the first cart during the collision is shown. The collision lasts from t_0 to t_2 . How many seconds did the collision last?



11. (10 points) A box of mass $m = 10 \text{ kg}$ is placed at rest on a ramp which makes an angle of **30 degrees** with the horizontal. The coefficients of friction between the ramp and box are $\mu_k = 0.15$ and $\mu_s = 0.35$. A force of **70 N** is then applied to the box, parallel to the ramp as shown.

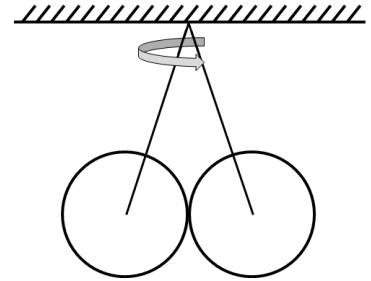


(a) Does the box move? Show that the box does or does not move.

(b) What is the magnitude of frictional force acting on the box?

12. (8 points) Two identical spheres, each of mass 3 kg and radius 0.05 m, are hung from their centers with 0.2 m long strings. The strings are fixed to the same spot on a platform above the two spheres. The platform, strings and spheres all begin to rotate with a very slowly increasing rate of rotation.

- (a) Draw a free body diagram for the left sphere. Draw the diagram assuming the apparatus is spinning, but the balls are still in contact (see part b). Each force should be labeled, in an appropriate direction. If there is, or is not, a net force in a direction, scale the forces to reflect this.



- (b) As the apparatus spins faster, the two spheres will lose contact with each other. At what (linear) speed are the balls travelling when this happens? Hint: what happens to the normal force between the spheres when they lose contact?