Do not turn the pages of the exam until you are instructed to do so.

Exam rules: You may use **only** a writing instrument while taking this test. You may **not** consult any calculators, computers, books, nor each other.

Problems 1 and 10 must be answered on the scantron form. **Problems 11 and 12 must be answered in exam booklet 1. Problem 13 must be answered in exam booklet 2.** The answers need to be well motivated and expressed in terms of the variables used in the problem. You will receive partial credit where appropriate, but only when we can read your solution. **Answers that are not motivated will not receive any credit, even if correct.**

At the end of the exam, you must hand in your exam, the scantron form, the blue exam booklets, and the equation sheet. **All items must be clearly labeled with your name, your student ID number, and the day/time/location of your workshop. If any of these items are missing, we will not grade your exam, and you will receive a score of 0 points.**

You are required to complete the following *Honor Pledge for Exams*. Copy and sign the pledge before starting your exam.

"I affirm that I will not give or receive any unauthorized help on this exam, and that all work will be my own."

Name: _____

Signature: _____

Good Luck !

Problem 1 (2.5 points) **Answer on Scantron form**

A person who weighs 450 N stands on a scale in an elevator. The scale will read zero if

1. the elevator is accelerating up at 9.8 m/s^2.
2. the elevator is moving at a constant speed of 9.8 m/s
3. the elevator is accelerating down at 9.8 m/s^2.
4. The scale will never read zero.

Problem 2 (2.5 points) **Answer on Scantron form**

Two satellites orbit the Earth in circular orbits of the same radius. One satellite is twice as massive as the other. Which statement is correct about the speeds of the satellites?

1. The heavier satellite moves twice as fast as the lighter one.
2. The two satellites have the same speed.
3. The lighter satellite moves twice as fast as the heavier one.
4. The ratio of their speeds depends on the details of how they were launched.

Problem 3 (2.5 points) **Answer on Scantron form**

Two stones, one twice the mass of the other, are dropped from a cliff. Just before hitting the ground, what is the kinetic energy of the heavy stone compared to the light one?

1. 1/4 as much.
2. 1/2 as much.
3. The same.
4. 2 times as much.
5. 4 times as much.

Problem 4 (2.5 points) **Answer on Scantron form**

A ball is thrown straight up. Neglecting air resistance, which statement is **NOT** true regarding the energy of the ball? You can ignore the effect of the drag force.

1. The potential energy decreases while the ball is going up.
2. The kinetic energy decreases while the ball is going up.
3. The sum of the kinetic energy and the potential energy is constant.
4. The potential energy decreases when the ball is coming down.
5. The kinetic energy increases when the ball is coming down.

Problem 5 (2.5 points) **Answer on Scantron form**

If all three collisions shown in Fig. 1 are totally inelastic, which collision(s) causes the most damage?

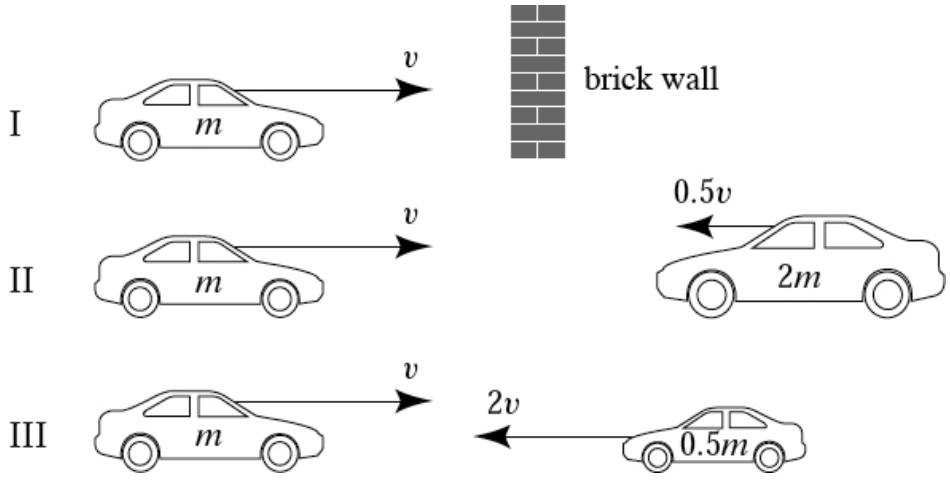

Figure 1: Totally inelastic collisions.

1. Collision I.
2. Collision II.
3. Collision III.
4. Collisions I and II.
5. Collisions I and III.
6. Collisions II and III.
7. Collisions I, II, and III.

Problem 6 (2.5 points) **Answer on Scantron form**

Figure 2 shows the paths of two colliding steel balls.

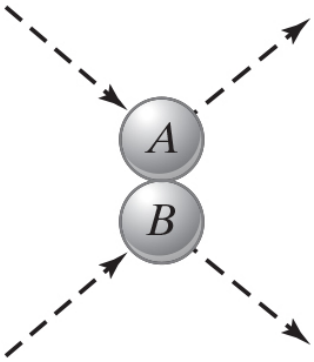

Figure 2: The collision between two steel balls.

Which set of arrows shown in Fig. 3 best represents the direction of the **change in the linear momentum** of each ball?

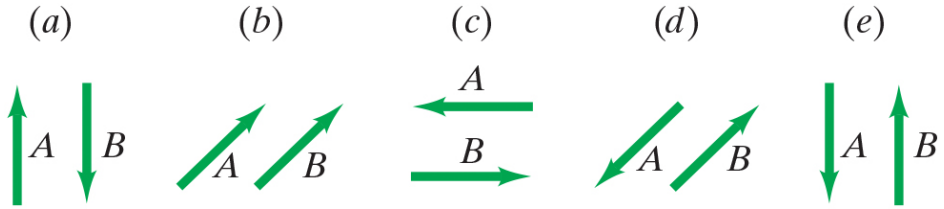

Figure 3: The change in the linear momenta of the two colliding steel balls.

1. (a).
2. (b).
3. (c).
4. (d).
5. (e).

Problem 7 (2.5 points) **Answer on Scantron form**

Figure 4 shows a roller-coaster car at 4 different positions along its track.

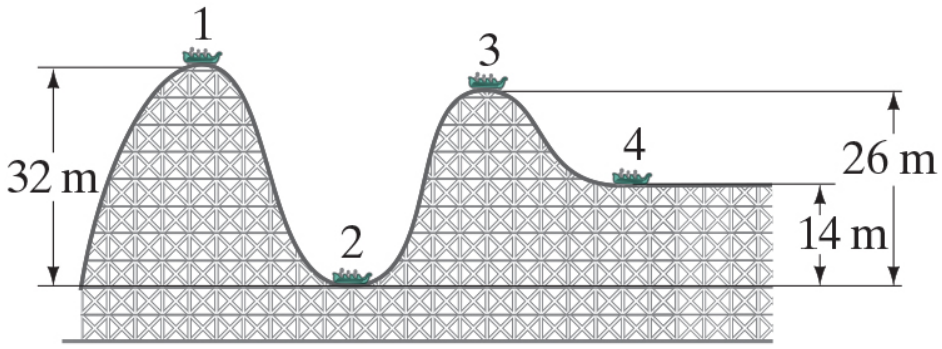

Figure 4: A roller coaster.

At which position is the kinetic energy of the roller-coaster car the largest? Assume there is no friction between the car and the track and that the effect of drag forces can be ignored.

1. Position 1.
2. Position 2.
3. Position 3.
4. Position 4.

Problem 8 (2.5 points) **Answer on Scantron form**

Figure 5 shows a potential energy distribution $U(x)$ as a function of x.

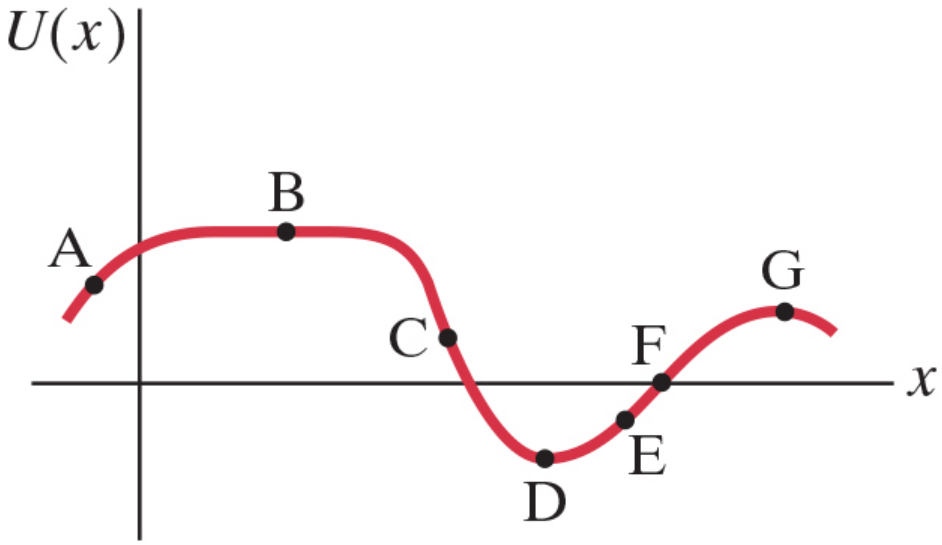

Figure 5: Potential energy U as function of position x.

At what point does the force F associated with this potential energy distribution have its greatest magnitude?

1. Point A.
2. Point B.
3. Point C.
4. Point D.
5. Point E.
6. Point F.
7. Point G.

Problem 9 (2.5 points) **Answer on Scantron form**

A delivery man carries a packge, as shown in Fig. 6.

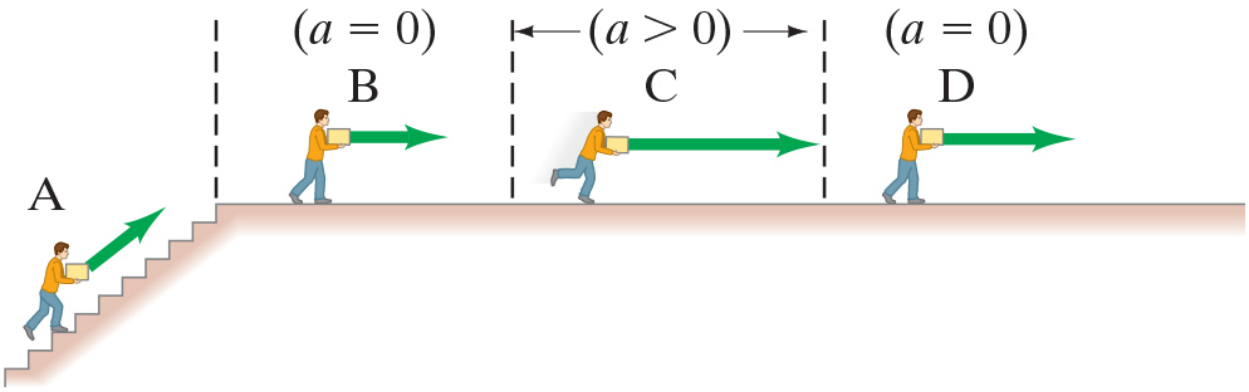

Figure 6: Delivering a package.

He walks up the stairs to the second floor at constant speed (A), and along the hall at a constant speed (B). He accelerates to a run (C) and then moves at a greater speed along the hall (D). During what portions of the motion is the delivery man doing work on the package?

1. A only.
2. B only.
3. C only.
4. D only.
5. A and C only.
6. B and C only.
7. None of these portions.
8. Work is done throughout.

Problem 10 (2.5 points) **Answer on Scantron form**

In what year were the Delta Werken completed?

Figure 7: The Oosterschelde kering.

1. 1953.
2. 1965.
3. 1971.
4. 1982.
5. 1997.
6. 2001.
7. 2010.
8. 2017.
9. 2025

Problem 11 (25 points) **Answer in booklet 1**

Several planets (Jupiter, Uranus, Saturn) possess nearly circular surrounding rings, perhaps composed of material that failed to form a satellite. In addition, many galaxies contain ring-like structures.
Consider a homogeneous ring of mass M and radius R, as shown in Fig. 8.

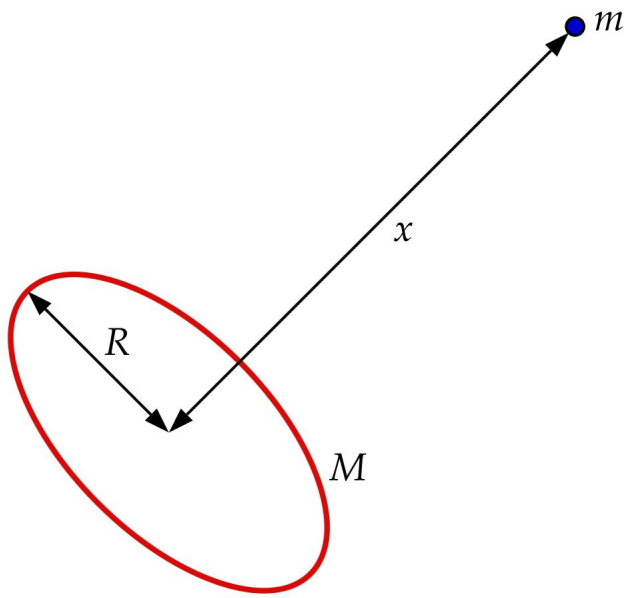

Figure 8: A homogeneous ring of matter exerting a force of particle m.

a) **(5 points)** What is the direction of the gravitational force exerted by the ring on a particle of mass m located a distance x from the center of the ring along its axis as shown in Fig. 8? **Make sure you motivate your answer!**

b) **(5 points)** What is the magnitude of the gravitational force exerted by the ring on the particle when it is located a distance x from the center of the ring along its axis?

c) **(5 points)** What is the potential energy of mass m as a function of the distance x?

d) **(10 points)** Suppose the particle falls from rest from its current distance x as a result of the attraction of the ring of matter. Find an expression for the speed with which it passes through the center of the ring. Note: assume that the ring remains stationary at all times.

Your answers should be well motivated and expressed in terms of the variables provided.

Problem 12 (25 points) **Answer in booklet 1**

A bullet of mass m is fired horizontally at two blocks resting on a smooth frictionless table top, as shown in Fig. 9. The bullet passes through the first block of mass M_1, and embeds itself in a second block of mass M_2. Speeds equal to v_1 and v_2, respectively, are thereby imparted on blocks M_1 and M_2, as shown in Fig. 9. **The mass removed from the first block by the bullet can be neglected.**

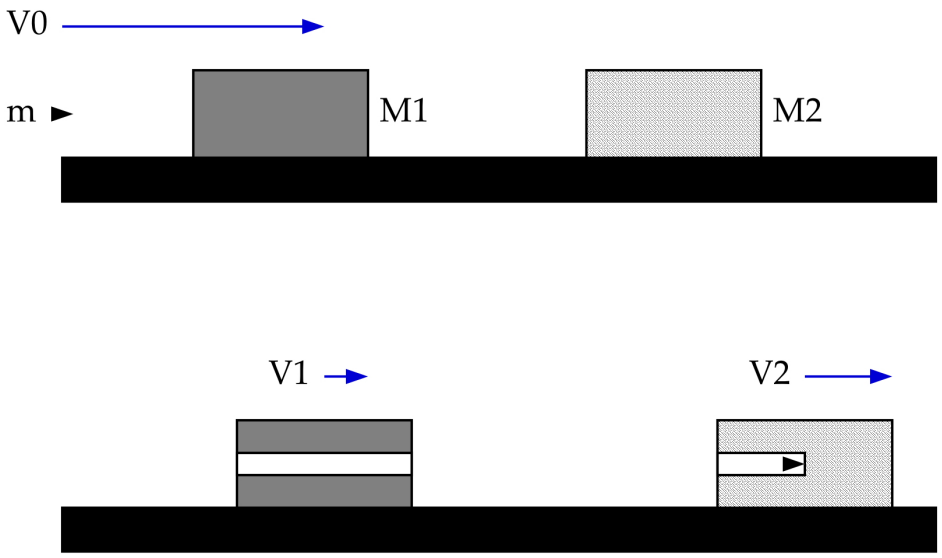

Figure 9: Shooting a bullet at two blocks.

a) **(10 points)** Find the speed of the bullet immediately after emerging from the first block. **Note: your answer to this question cannot contain v_0 since this is not one of the variables provided.**

b) **(15 points)** Find the initial speed v_0 of the bullet.

Your answers should be well motivated and expressed in terms of the variables provided.

Problem 13 (25 points) **Answer in booklet 2**

Consider the track shown in Fig. 10. Section AB is one quadrant of a circle of radius r and is frictionless. Section BC is a horizontal surface of length L with a coefficient of kinetic friction μ_k. Section CD, under the spring, is frictionless.

Figure 10: Motion of a block on a track.

A block of mass m is released from rest at A. After sliding on the track, it is observed to compress the spring by a distance d.

a) **(5 points)** What is the speed of the block at point B?

b) **(5 points)** What is the work done by the friction force as the block slides from point B to point C?

c) **(5 points)** What is the speed of the block at point C?

d) **(10 points)** What is the spring constant k?

Your answers should be well motivated and expressed in terms of the variables provided.

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Figure 11: A KLM Boeing 747 landing where? Photo made by Frank Wolfs.