INSTRUCTIONS:

This exam contains 25 multiple-choice questions plus 2 extra credit questions, each worth 3 points. Choose one answer only for each question. Choose the best answer to each question. Answer all questions.

Allowed material: Before turning over this page, put away all materials except for pens, pencils, erasers, rulers and your calculator. There is a formula sheet attached at the end of the exam. Other copies of the formula sheet are not allowed.

Calculator: In general, any calculator, including calculators that perform graphing, is permitted. Electronic devices that can store large amounts of text, data or equations (like laptops, palmtops, pocket computers, PDA or e-book readers) are NOT permitted. If you are unsure whether or not your calculator is allowed for the exam, ask your TA.

How to fill in the bubble sheet:
Use a number 2 pencil. Do NOT use ink. If you did not bring a pencil, ask for one.
Write and fill in the bubbles corresponding to:
- Your last name, middle initial, and first name.
- ★ ★ Your ID number (the middle 9 digits on your ISU card) ★ ★
- Special codes K to L are your recitation section. Always use two digits (e.g. 01, 09, 11, 13). Honors sections: H1 → 02; H2 → 13; H3 → 25; H4 → 06; H5 → 49

Please turn over your bubble sheet when you are not writing on it.

If you need to change any entry, you must completely erase your previous entry. Also, circle your answers on this exam. Before handing in your exam, be sure that your answers on your bubble sheet are what you intend them to be. You may also copy down your answers on the table at the end of the exam and take them with you to compare with the posted answers.

When you are finished with the exam, place all exam materials, including the bubble sheet, and the exam itself, in your folder and return the folder to your recitation instructor.

No cell phone calls allowed. Either turn off your cell phone or leave it at home. Anyone answering a cell phone must hand in their work; their exam is over.

Best of luck,

Drs. Eli Rosenberg, Kerry Whisnant, and Kai-Ming Ho
1. Which one of the following vectors is perpendicular to $\vec{A} = 5\hat{i} - 3\hat{j} + \hat{k}$?

A) $\hat{i} + 2\hat{j} + \hat{k}$  
B) $-5\hat{i} + 3\hat{j} - \hat{k}$  
C) $3\hat{i} + 2\hat{j} + \hat{k}$  
D) $2\hat{i} + 3\hat{j} - 2\hat{k}$  
E) $2\hat{i} + \hat{j} - 4\hat{k}$

2. In the graph at the right, the velocity is zero at points:

A) B and F  
B) A, C, E, G, and I  
C) D and H  
D) B, D, F, and H  
E) It is not possible to say

3. A ball is thrown directly upward off the roof of a tall building at $t = 0$. The ball reaches its maximum height at $t = 1.5$ s, and hits the ground at the bottom of the building at $t = 4.2$ s. How tall is the building, in m? Assume there is no air resistance.

A) 86  
B) 11  
C) 25  
D) 36  
E) 50
4. The acceleration of a particle is given by \( a_x = 5.00 \, t^2 + 3.00 \), where the units of the constants have the proper units to give SI units. At \( t = 3.00 \, \text{s} \), the particle has an initial velocity of 50.0 m/s. What is the change in velocity during the interval \( t_1 = 3.00 \, \text{s} \) and \( t_2 = 7.00 \, \text{s} \), in m/s?

A) 589  
B) 1.59 \times 10^3  
C) 539  
D) 1.64 \times 10^3  
E) 40.0

5. A ball is thrown directly upward. When the ball returns to its original height, which one of the following statements is true? Assume there is no air resistance.

A) The final speed is larger than the initial speed.  
B) The final speed is equal to the initial speed.  
C) The final speed is less than the initial speed.  
D) The final acceleration is in the opposite direction from the initial acceleration.  
E) The final acceleration approaches zero as the ball returns to its initial height.

6. “A pint’s a pound the world around” is used to approximate the weight of water. If it were exactly true, what would the density (mass per unit volume) of water be in SI units? (There are 8 pints in a gallon.)

A) 0.125 kg/m\(^3\)  
B) 1.0 kg/m\(^3\)  
C) 9.8 kg-m/s\(^2\)  
D) 9.8 kg/m\(^3\)  
E) 9.6 \times 10^2 kg/m\(^3\)
7. Which one of the following statements is true?

A) The vector sum of the tangential acceleration and the centripetal acceleration can be zero for a point on a rotating disk.
B) All points on a rotating disk have the same angular velocity.
C) All points on a rotating disk have the same linear speed.
D) All points on a rotating car tire have zero acceleration if the car is moving with constant linear velocity.
E) All points on a rotating disk experience the same radial acceleration.

8. Vector $\vec{A}$ lies in the x-y plane, has magnitude 2.00, and makes an angle of 60.0° with the positive x-axis (in the counterclockwise direction), and vector $\vec{B} = 3.00\hat{t} - 5.00\hat{j}$. What is the value of $\vec{A} \cdot (\vec{B} \times \vec{A})$?

A) -10.2 $\hat{k}$
B) 20.4
C) 10.2
D) 0
E) -10.2 $\hat{t}$ - 17.7 $\hat{j}$

9. A merry-go-round has an initial angular speed of 1.8 rad/s. It undergoes constant angular acceleration for 300 s, during which time it makes 74 revolutions. What is the final angular speed, in rad/s?

A) 0.92
B) 0
C) -1.3
D) 1.3
E) 3.4
10. A snowboarder takes exactly 2.50 seconds to complete a trick (from launch to landing). The snowboarder leaves the ramp at an angle of 45° above the horizontal and lands 10.0 m below his starting point. What is his take-off speed, in m/s?

A) 11.7
B) 8.25
C) 23.0
D) 1.27
E) 5.02

11. A man pulls a box across a horizontal floor at a constant speed of 2.5 m/s. The box has mass 14 kg and the coefficient of kinetic friction between the box and the floor is $\mu_k = 0.17$. What is the power output of the man, in W?

A) 19
B) 28
C) 35
D) 58
E) $1.4 \times 10^2$

12. A person sits at rest on a chair. The gravitational force on the person (his/her weight) is one half of an action-reaction pair. Which force is the other half?

A) The downward force that the chair exerts on the ground
B) The upward force exerted by the chair on the person
C) The upward force that the person exerts on the Earth
D) The downward force that the person exerts on the chair
E) The upward force exerted by the ground on the chair
13. A boat must cross a 50-m-wide river and arrive at a point 20 m upstream from where it starts (see figure). To do so, the pilot must aim the boat at an upstream angle of $\theta = 40^\circ$. The boat has speed 4.5 m/s in still water.

What is the speed of the current, in m/s?

A) 1.5  
B) 2.1  
C) 3.3  
D) 1.2  
E) 2.6

14. For general projectile motion, which of the following best describes the horizontal component of a projectile's acceleration? Assume air resistance is negligible.

A) It continually decreases.  
B) It remains a nonzero constant.  
C) It continually increases.  
D) It is zero.  
E) It initially decreases and then increases.

15. What is the car in the diagram doing if a helium balloon attached to the floor by a string is in the position shown?

A) Traveling forward and slowing down  
B) Traveling forward at constant speed  
C) Traveling backward at constant speed  
D) Traveling backward and slowing down  
E) Sitting still
16. A block of mass $m_1 = 3.5$ kg is pushed by a force $F = 36$ N against another block of mass $m_2 = 2.5$ kg, as shown. What is the force exerted on mass $m_2$ by the mass $m_1$, in N?

A) 9.0  
B) 27  
C) 36  
D) 21  
E) 15

17. A box is sitting at rest on a table inside an elevator that is moving downward and slowing down. Which of the following statements is true?

A) The normal force of the book on the table is less than the weight of the book.  
B) The normal force of the book on the table is equal to the weight of the book.  
C) The normal force of the book on the table is greater than the weight of the book.  
D) The normal force of the book on the table depends on the speed of the elevator.  
E) The normal force of the book on the table is less than the normal force of the table on the book.

18. A 0.30 kg rock is swung in a circular path in a vertical plane on a 0.25 m length string. At the bottom of the path, the angular velocity is 15 rad/s. What is the tension in the string, in N, at that point?

A) 0  
B) 33  
C) 20  
D) 14  
E) 8.5
19. A sports car weighing 7000 N goes around a flat curve with speed 22 m/s. The curve has a radius of curvature of 350 m. What is the minimum coefficient of static friction between the tires and the road that will prevent the car from sliding off the road?

A) 0.11  
B) 0.14  
C) 0.20  
D) 0.26  
E) 0.33

20. A graph of the force on an object as a function of its position is shown in the figure. Determine the amount of work done by this force, in J, on an object that moves from $x = 0.0$ m to $x = 6.0$ m.

A) 27  
B) 54  
C) 18  
D) 22  
E) 36

21. Consider the block on the incline pictured below. When the block is released from rest (at the top of the incline) it slides down the incline. There is friction between the block and the incline as it slides down. Which one of the following statements is true?

A) The work done by the normal force is positive.  
B) The coefficient of static friction is zero.  
C) The kinetic energy at the bottom is equal to the kinetic energy at the top.  
D) The work done by friction is positive.  
E) The work done by gravity is positive.
22. Three blocks with masses \( m \), \( 2m \) and \( 3m \) are connected through two massless ropes that pass through two massless, ideal pulleys as shown in the figure. There is no friction between the blocks and the table. What is the net force on the 3m block?

A) \( mg \) to the left
B) \( mg/2 \) to the left
C) 0
D) \( 3mg \) to the left
E) \( mg \) to the right

Questions 23 and 24 refer to the diagram below. Two masses are placed on an inclined plane and a pulley as shown. The incline makes an angle of \( \theta = 30^\circ \) with the horizontal and the coefficient of kinetic friction between the box and the incline is \( \mu_k = 0.10 \). The coefficient of static friction between the box and the incline is \( \mu_s = 0.20 \). Let \( m = 5.0 \text{ kg} \). The 2m box slides a distance of 1.3 m down the incline.

23. The frictional force acting on the incline is

A) 4.9 N up the incline
B) 8.5 N down the incline
C) 4.9 N down the incline
D) 0
E) 9.8 N down the incline

24. What is the work done by gravity on box \( m \), in J?

A) 13
B) -26
C) 49
D) -64
E) 98
25. Which of the following free-body diagrams is possible for the car (at right) traveling around a banked corner?

A) \hspace{1cm} B) \hspace{1cm} C) \hspace{1cm} D) \hspace{1cm} E)

26. A rock is thrown straight up with speed 20.0 m/s from ground level at t = 0. A second rock is thrown straight up from ground level at t = 1.00 s and hits the first rock just as the first rock reaches its highest point. What was the initial speed of the second rock, in m/s?

A) 39.4
B) 47.1
C) 31.3
D) 20.0
E) 24.7

27. A mass of 4.0 kg, initially at rest, is attached to a spring that has spring constant $k = 90 \text{ kg/s}^2$. If the spring is initially extended by 50 cm from equilibrium and at a later time is compressed by 30 cm, what is the final speed of the mass, in m/s?

A) 1.3
B) 1.9
C) 0
D) 2.1
E) 3.4
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