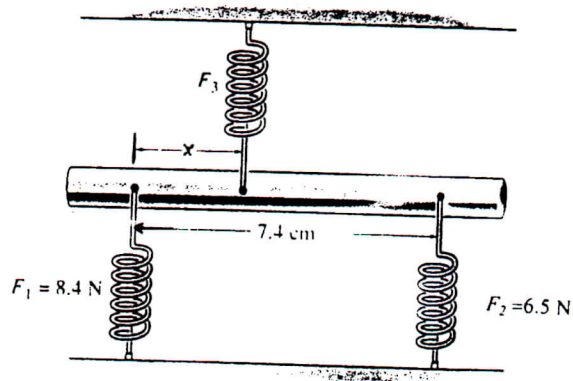




The answers should be entered carefully on a computer readable sheet using an HB pencil. At the end of the examination, only computer sheet should be handed over to a proctor. The student can keep this questionnaire.

- Rain falls vertically at a constant speed of 10.0 m/s. A tube is mounted on a railcar moving horizontally at a constant speed of 20.0 m/s. At what angle with respect to the horizontal direction should the tube be tilted so that water does not reach the sides of the tube?  
A) 63.4°  
B) 30.0°  
 C) 26.6°  
D) 60.0°  
E) none of the above
- A small rubber ball of mass  $m$  is put on top of a volleyball of mass  $M$  ( $M$  is much larger than  $m$ ). This combination is then dropped from height  $h$ . The small ball ideally rebounds (perfect elastic collision) to the height  
A)  $h$ .  
B)  $2h$ .  
C)  $3h$ .  
D)  $4h$ .  
 E)  $9h$ .
- A solid disk and a ring roll down an incline. The ring is slower than the disk if  
A)  $m_{ring} = m_{disk}$ , where  $m$  is the inertial mass.  
B)  $r_{ring} = r_{disk}$ , where  $r$  is the radius.  
C)  $m_{ring} = m_{disk}$  and  $r_{ring} = r_{disk}$ .  
 D) The ring is always slower regardless of the relative values of  $m$  and  $r$ .

4. Which is larger for a hoop (ring) of mass  $M$  and radius  $R$  that is rolling without slipping: its translational or its rotational kinetic energy?
- A) Its translational kinetic energy.  
 B) Its rotational kinetic energy.  
 C) Both are the same size.  
 D) The answer depends on the radius.  
 E) The answer depends on the mass.
5. Inside a piece of machinery, a metal rod is secured in the horizontal plane by three horizontal springs, as shown below (the entire structure lies in the horizontal plane and the forces  $F_1$ ,  $F_2$ , and  $F_3$  are the tensions in the springs). Find the point of attachment  $x$  for the upper spring that will maintain the rod in static equilibrium.



- A) 2.9 cm  
 B) 3.5 cm  
 C) 7.4 cm  
 D) 3.2 cm  
 E) none of the above

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6. A student tosses a ball straight up and just outside her dormitory window, with an initial velocity of 3.90 m/s. How long after it was thrown will it hit the ground, 8.60 m below the window?
- A) 1.78 s  
B) 1.68 s  
C) 1.58 s  
D) 1.88 s  
E) none of the above
7. The angular momentum vector for a spinning wheel lies along its axle and is pointed east. In order to make this vector point south, in which direction is it necessary to exert a force on the east end of the axle?
- A) up  
B) down  
C) north  
D) south  
E) east
8. A ball is dropped from rest at the top of a 6.10-m-tall building. It falls straight down, collides inelastically with the ground and bounces back. The ball loses 15.0% of its kinetic energy every time it collides with the ground. How many bounces can the ball make and still reach a window sill that is 2.44 m above the ground?
- A) 8  
B) 7  
C) 6  
 D) 5  
E) 4
9. A rocket exhausts fuel with a velocity of  $1.50 \times 10^3$  m/s relative to the rocket. It starts from rest in outer space with fuel comprising 60% of the total mass. When all the fuel has been exhausted, its speed (in m/s) is
- A)  $3.45 \times 10^3$   
 B)  $1.37 \times 10^3$   
C)  $1.81 \times 10^3$   
D)  $1.50 \times 10^3$   
E) none of the above

- 
10. A 2.0-kg block is traveling to the right at 5.0 m/s, and a second 3.0-kg block is traveling to the left at 4.0 m/s. The speed of the 2.0-kg block relative to the center of mass is
- A) 9.0 m/s
  - B) 1.0 m/s
  - C) 5.0 m/s
  - D) 3.6 m/s
  - E) 5.4 m/s
11. When a 4.0-kg mass is hung vertically on a light spring that obeys Hooke's law, the spring stretches 2.0 cm. How much work (in J) must an external agent do to stretch the spring 3.0 cm from its equilibrium position?
- A) 0.78
  - B) 1.76
  - C) 2.06
  - D) 3.14
  - E) none of the above
12. The acceleration of a marble in a certain fluid is proportional to its velocity squared, and is given (in  $\text{m/s}^2$ ) by  $a = -3v^2$  for  $v > 0$ . If the marble enters this fluid with a speed of 1.50 m/s, how long will it take before the marble's speed is reduced to one-fourth of its initial value?
- A) 0.22 s
  - B) 0.67 s
  - C) 0.81 s
  - D) 0.94 s
  - E) none of the above

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13. A 750-kg wrecking ball is suspended from a 25-m chain of negligible mass. The ball is hanging vertically, resting against the wall of a building. It is then withdrawn a distance much smaller than the chain length and released. How soon does it strike the building?
- A) 2.2 s
  - B) 2.5 s
  - C) 3.0 s
  - D) 3.7 s
  - E) none of the above
14. A torsional pendulum consists of a solid disk (mass = 2 kg and radius = 1 m) suspended at its center by a wire attached to a rigid support. The disk oscillates about the support wire. If the torsion constant is 9 N·m, what is the *angular* frequency (in rad/s)?
- A) 3
  - B) 2
  - C) 1
  - D) 4
  - E) none of the above
15. A space shuttle is in a circular orbit 500 km above Earth's surface. What is its orbital period?
- A)  $8.6 \times 10^4$  s
  - B)  $4.3 \times 10^4$  s
  - C)  $9.1 \times 10^3$  s
  - D)  $7.2 \times 10^3$  s
  - E)  $5.7 \times 10^3$  s
16. The condition of apparent weightlessness for the passengers can be created for a brief instant when a plane flies over the top of a vertical circle. At a speed of 215 m/s, what is the radius of the vertical circle that the pilot must use?
- A) 2750 m
  - B) 3140 m
  - C) 3730 m
  - D) 4270 m
  - E) 4720 m

February 24, 2012  
Supplemental Examination: 3 hours

Dr. Z.M. Stadnik  
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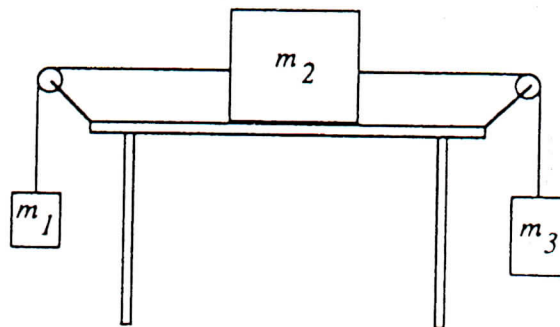
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17. The approximate value of  $g$  (in  $\text{m/s}^2$ ) at an altitude above the earth equal to one earth diameter is
- A) 9.8
  - B) 4.9
  - C) 2.5
  - D) 1.9
  - E) 1.1
18. An object of mass  $3m$ , initially at rest, explodes breaking into two fragments of mass  $m$  and  $2m$ , respectively. Which statement concerning the *fragments after the explosion* is true?
- A) They may fly off at right angles.
  - B) They may fly off in the same direction.
  - C) The larger fragment will have twice the speed of the smaller fragment.
  - D) The smaller fragment will have twice the speed of the larger fragment.
  - E) The smaller fragment will have four times the speed of the larger fragment.
19. The rotational inertia of a rigid body
- A) is a measure of its resistance to changes in rotational motion.
  - B) depends on the location of the axis of rotation.
  - C) is large if most of the body's mass is far from the axis of rotation.
  - D) is all of the above.
  - E) is none of the above.
20. A solid cylinder made of lead has the same mass and the same length as a solid cylinder made of wood. The rotational inertia of the lead cylinder compared to the wooden one is
- A) greater.
  - B) smaller.
  - C) the same.

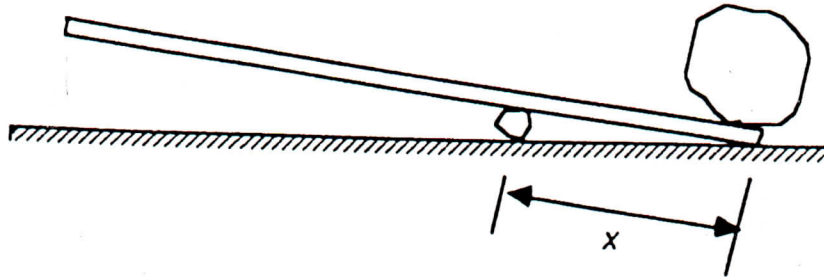
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21. A woman sits on a spinning piano stool with her arms folded. When she then extends her arms, which of the following statements is true?
- A) She increases her moment of inertia, thereby increasing her angular speed.
  - B) She increases her moment of inertia, thereby decreasing her angular speed.
  - C) She decreases her moment of inertia, thereby increasing her angular speed.
  - D) She decreases her moment of inertia, thereby decreasing her angular speed.
  - E) Both her moment of inertia and her angular speed remain constant.
22. A simple pendulum has length  $L$  and period  $T$ . As it passes through its equilibrium position, the string is suddenly clamped at its mid-point. The period then becomes
- A)  $2T$ .
  - B)  $T$ .
  - C)  $T/2$ .
  - D)  $T/4$ .
  - E) none of the above
23. If the mass of a planet is doubled with no increase in its size, the escape speed for that planet will
- A) be increased by a factor of 1.4.
  - B) be increased by a factor of 2.0
  - C) not be changed.
  - D) be reduced by a factor of 1.4.
  - E) be reduced by a factor of 2.0.
24. If a particle that is moving with uniform circular motion has a constant speed,
- A) the force on the particle is zero.
  - B) the acceleration of the particle is zero.
  - C) the acceleration, which is constant in magnitude, is at right angles to the direction of the velocity.
  - D) the tangential acceleration equals the centripetal acceleration.
  - E) none of these is correct

25. A car is accelerating at a rate of  $2.5 \text{ m/s}^2$ . A mass of 250 g is hanging from the ceiling on a string 1.2 m long. The angle that the string makes with the vertical is
- A)  $14^\circ$  toward the back of the car.  
 B)  $76^\circ$  toward the back of the car.  
 C)  $7^\circ$  toward the front of the car.  
 D)  $14^\circ$  toward the front of the car.  
 E)  $0^\circ$  or straight down.
26. A 5.0-kg crate is resting on a horizontal plank. The coefficient of static friction is 0.50 and the coefficient of kinetic friction is 0.40. After one end of the plank is raised so the plank is  $25^\circ$  above the horizontal, the force of friction is
- A) 0  
 B) 18 N  
 C) 21 N  
 D) 22 N  
 E) 44 N
27. For this problem, assume there is no friction. A mass  $m_2 = 3.5 \text{ kg}$  rests on a horizontal table and is attached by strings to masses  $m_1 = 1.5 \text{ kg}$  and  $m_3 = 2.5 \text{ kg}$  as shown. The masses  $m_1$  and  $m_3$  hang freely. The system is initially held at rest. After it is released, the acceleration of mass  $m_2$  is

- A) zero.  
 B)  $1.3 \text{ m/s}^2$ .  $1.1 \times 2$   
 C)  $5.2 \text{ m/s}^2$ .  $9.1 \times 2$   
 D)  $8.7 \text{ m/s}^2$ .  $3.1 \times 2$   
 E)  $9.8 \text{ m/s}^2$ .  $3.5 \times 9$



28. A farmer wishes to move a boulder weighing 3800 N. She has a 3-m pole that she will use as a lever, and she is able to exert a 670 N force on the lever. How far from the end of the pole under the boulder must she put another rock to serve as a pivot in order to lift the boulder?



- A) 0.45 m  
 B) 0.53 m  
 C) 1.0 m  
 D) 2.55 m  
 E) 0.05 m
29. A man riding in an elevator has an apparent weight greater than his actual weight. Which of the following statements could be true?
- A) The elevator moves upward with constant speed.  
 B) The elevator moves downward with constant speed.  
 C) The elevator moves upward with decreasing speed.  
 D) The elevator moves downward with decreasing speed.  
 E) The elevator moves downward with increasing speed.
30. The total energy of a simple harmonic oscillator could be doubled by increasing the amplitude by a factor of
- A) 0.71  
 B) 1.00  
 C) 1.41  
 D) 2.00  
 E) 4.00

31. Clocks with basic time-keeping mechanisms consisting of a mass on a spring and a simple pendulum are taken to the top of a mountain. At the base of the mountain, they both keep perfect time. At the top of the mountain,
- A) neither keeps correct time.
  - B) only the pendulum clock keeps correct time.
  - C) only the mass-spring clock keeps correct time.
  - D) both keep correct time.