3-digit CID#_____

You are allowed pencils and a testing center calculator (should be provided without charge). No scratch paper is allowed. If you need more paper, you may separate the exam and use backs of paper then restaple exam. A foreign language dictionary is allowed if English is not your native language.

Do all your work on the exam itself. When you are confident you have found the correct answer, fill in the appropriate bubble on the scantron sheet. Check your work. No partial credit given.

Carry three significant figures throughout your calculations; for example 2 m means 2.00 m, and don’t round 431 to 430
1. A boy puts a bowling ball (m = 3 kg, R = 0.08 m) on the floor, and starts it spinning faster and faster with the tangential friction force of his two hands. He does this for 4 seconds, and then the ball is spinning at 50 rad/sec. The average force \( f \) from one of his hands is _______ N.
   a) 0 to 1
   b) 1 to 2
   c) 2 to 3
   d) 3 to 4
   e) 4 to 5
   f) 5 to 6
   g) more than 6

2. Two cars are exactly the same make and model, and their drivers weigh the same. But one has special large, massive wheels and the other has special small, light wheels. If they have the same speed, which one will roll further up a hill if the engines and brakes are not used? _______
   a) big wheeled car
   b) small wheeled car
   c) same height

3. The kinetic energy of solid disk of mass 2 kg rolling at a speed of 4 m/s is ______ J
   a) 0 to 5
   b) 5 to 10
   c) 10 to 15
   d) 15 to 20
   e) 20 to 25
   f) 25 or more

4. An elevator of mass 200 kg is attached by a cable to a large flywheel of I = 700 kgm² and radius of 0.5 m. In an accident, the brakes fail, and the elevator falls and makes the flywheel rotate as the cable unwinds. When the elevator has fallen 15 m, it is going _______ m/s.
   a) 0 to 5
   b) 5 to 10
   c) 10 to 15
   d) 15 to 20
   e) 20 to 25
   f) 25 or more

5. Four masses, each 3 kg are attached to a light square frame with sides of 1 m. If you rotate this about an axis through the center (dot in drawing), perpendicular to the plane of the square, the moment of inertia is ________ kg m²
   a) 0 to 5
   b) 5 to 10
   c) 10 to 15
   d) 15 to 20
   e) 20 to 25
   f) 25 or more

6. An ice skater with her arms extended is spinning at a rate of 1 rev/s. Her moment of inertia about her center is 2 kg m². When she pulls her arms in, she starts to spin at a rate of 2.5 revs/s. Her new moment of inertia is ________ kg m².
   a) 0 to 2
   b) 1 to 2
   c) 2 to 3
   d) 3 to 4
   e) more than 4
7. (continued) The skater does ________ J of work during the process. Be careful with units.
   a) 0 to 20
   b) 20 to 40
   c) 40 to 60
   d) 60 to 80
   e) 80 to 100
   f) more than 100

8. You are quite lazy, but have been paying attention in your physics class. You’re sitting in your chair and instead of getting up to open your door (moment of inertia 7.67 kg m²), you throw a 3 kg piece of clay 5 m/s in a line perpendicular to the door, and it sticks to the door 0.75 m from the hinge. Your door is now opening at _______ rads/s
   a) 0 to 0.25
   b) 0.25 to 0.35
   c) 0.35 to 0.45
   d) 0.45 to 0.55
   e) 0.55 to 0.65
   f) 0.75 to 0.85
   g) more than 0.85

9. We place satellites in orbit around the earth. The more massive satellites must be placed at
   a) lower orbits
   b) higher orbits
   c) neither (no satellite mass dependence)

10. Pluto’s mass is 1.305 x 10²² kg (only 0.22 % that of earth). Pluto’s radius is 1150 km (only 18% that of Earth’s.) The acceleration due to gravity for a ball you throw on Pluto’s surface would be ______ m/s²
    a) 0 to 0.1
    b) 0.1 to 0.2
    c) 0.2 to 0.4
    d) 0.4 to 0.8
    e) 0.8 to 1.6
    f) 1.6 to 3.2
    g) more than 3.2

11. You have a spring of unknown spring constant attached to the bottom of a pool of water. When you attach a 1 kg block of wood (ρ = 795 kg/m³) to the spring, you notice that the spring stretches. The buoyant force on the wood block is ________ N
    a) 0 to 5
    b) 5 to 10
    c) 10 to 15
    d) 15 to 20
    e) 20 to 25
    f) more than 25

12. (continued) The spring stretches 2 cm. Therefore, the spring constant is ________ N/m.
    a) 0 to 110
    b) 110 to 120
    c) 120 to 130
    d) 130 to 140
    e) 140 to 150
    f) more than 150

13. (continued) If you replace the wood block by a steel block of the same size, the buoyant force will
    a) increase
    b) decrease
    c) stay the same
14. If the tanks are identical, which of the following is true concerning the pressure on the bottom? The tubes are open to the air.

\[ \rho_{\text{water}} = 1000 \text{ kg/m}^3 \]
\[ \rho_{\text{oil}} = 790 \text{ kg/m}^3 \]

- a) \( P_{\text{water}} > P_{\text{oil}} \)
- b) \( P_{\text{water}} = P_{\text{oil}} \)
- c) \( P_{\text{water}} < P_{\text{oil}} \)
- d) depends on the tank size

15. A certain fluid has a density of 700 kg/m³. On Mars, where \( g = 3.7 \text{ m/s}^2 \), and the atmospheric pressure is 600 Pa, you could suck this fluid up a straw or tube to a height of ___ m above the liquid.

- a) 0 to 0.1
- b) 0.1 to 0.2
- c) 0.2 to 0.4
- d) 0.4 to 0.8
- e) 0.8 to 1.6
- f) 1.6 to 3.2
- g) more than 3.2

16. Consider the following pipe through which water is flowing:

If \( R = 10 \text{ cm} \) and \( r = 1 \text{ cm} \), \( \frac{v_2}{v_1} = \) ____.

\[ \rho_{\text{water}} = 1000 \text{ kg/m}^3 \]

- a) 0 to 20
- b) 20 to 60
- c) 60 to 120
- d) 120 to 160
- e) more than 160

17. (continued) \( P_2 = 130 \text{ kPa} \) at the narrow portion on the right. If during each second, one kg of water flows through the system, \( P_1 = \) ______ kPa.

- a) 0 to 128
- b) 128 to 130
- c) 130 to 132
- d) 132 to 134
- e) 134 to 136
- f) more than 136

18. A large water tower has a water level 50 m above the ground and is open at the top. A valve of radius 3 cm is opened at ground level to drain it. If there is no friction, it will start to drain at a rate of ____ m³/minute.

- a) 0 to 2
- b) 2 to 4
- c) 4 to 8
- d) 8 to 10
- e) 10 to 12
- f) more than 12
19. Two pipes of the same length are each connected to a pressurized tank, and carry viscous pancake syrup from it to the bottles for packing. Speeds are low enough to ignore the Bernoulli effect. One tube is two times as wide as the other. How much faster will the larger tube fill syrup bottles than the narrow tube?
   a) 1x (no faster)
   b) \( \sqrt{2} \) x
   c) 2 x
   d) 4 x
   e) 8 x
   f) 16x
   g) 32 x
   h) more than 32 x

20. The most important feature of a wing to provide lift is its_______
   a) ability to deflect air downward
   b) thickness
   c) curved shape

21. As a moon of mass \( m \) goes around a planet of mass \( M \), it has an angular velocity \( \omega \). Which equation is true?
   a) \( \omega = \sqrt{\frac{GM}{r^3}} \)
   b) \( \omega = \frac{GM}{r^3} \)
   c) \( \omega = \frac{GM}{r^2} \)
   d) \( \omega = \sqrt{\frac{GM}{r^2}} \)
   e) \( \omega = \sqrt{\frac{GM}{mr^2}} \)
   f) \( \omega = \frac{GmM}{r^2} \)
   g) \( \omega = \frac{GmM}{r^3} \)
   h) \( \omega = \sqrt{\frac{GM}{mr^2}} \)

22. A gymnast (essentially a uniform rod of mass \( M \) and length \( L \)) is vertical on the high bar, standing on his hands. He swings without friction or changing shape down to hanging vertically below the bar, and at this point his feet have a speed of
   a) \( \sqrt{gL} \)
   b) \( \sqrt{2gL} \)
   c) \( \sqrt{3gL} \)
   d) \( 2\sqrt{gL} \)
   e) \( \sqrt{5gL} \)
   f) \( \sqrt{6gL} \)
   g) \( \sqrt{7gL} \)

23. In which of the following is the net torque the largest?
   a) I
   b) II
   c) Same
24. Mark ALL that are true (Σ means sum)
   a) The Σ F on an object can be zero and the Σ τ be nonzero.
   b) The Σ τ on an object can be zero and the Σ F be nonzero.
   c) The Σ τ on an object determines how the center of mass accelerates

25. You (60 kg) and your little brother (30 kg) are playing on a uniform teeter-totter that is balanced exactly at the middle. Your brother sits down on one end. You must sit _____ m from the pivot so that it balances. The length of the teeter-totter is 3 m.
   a) 0 to 0.2
   b) 0.2 to 0.4
   c) 0.4 to 0.6
   d) 0.6 to 0.8
   e) 0.8 to 1.0
   f) 1.0 to 1.2
   g) more than 1.2

26. If the tension in the upper rope is 650 N, and the weight of the beam is 200N, the hanging weight must be _____ N.
   a) 0 to 100
   b) 100 to 200
   c) 200 to 300
   d) 300 to 400
   e) 400 to 500
   f) 500 to 600
   g) more than 600

27. (continued) The horizontal (x) force of the pivot on the beam must be ________ N
   a) 0 to 100
   b) 100 to 200
   c) 200 to 300
   d) 300 to 400
   e) 400 to 500
   f) 500 to 600
   g) more than 600

28. Shortly after deployment a satellite is set spinning to help it stabilize its pointing direction. If it accelerates while turning a total of 200 revolutions in 60 seconds, the angular acceleration is _____ revolutions/s²
   a) 0 to 0.2
   b) 0.2 to 0.4
   c) 0.4 to 0.6
   d) 0.6 to 0.8
   e) 0.8 to 1.0
   f) 1.0 to 1.2
   g) more than 1.2
   44 good

29. 4 radians is the same as _______ degrees
   a) 0 to 10
   b) 10 to 20
   c) 20 to 40
d) 40 to 80
e) 80 to 160
f) 160 to 320
g) more than 320

30. A ball of radius 0.18 m is rolling at a speed of 8 m/s. Its angular velocity is ______ rad/sec.
   a) 0 to 20  d) 30 to 35
   b) 20 to 25  e) 35 to 40
   c) 25 to 30  f) more than 40

31. A roller coaster goes over the top of a hill with radius of curvature r. Which equation describes the normal force the riders feel?
   a) \( N = \frac{mv^2}{r} \)
   b) \( N - mg = \frac{mv^2}{r} \)
   c) \( mg - N = \frac{mv^2}{r} \)
   d) \( N + mg = \frac{mv^2}{r} \)
   e) \( N + mg = -\frac{mv^2}{r} \)

32. You twirl a ball of mass 0.5 kg on a string, length 2 m around your head in a horizontal circle, at a constant speed of 3 m/s. The tension in the string is ______ N.
   a) 0 to 2  e) 5 to 6
   b) 2 to 3  f) 6 to 7
   c) 3 to 4  g) more than 7
   d) 4 to 5

33. A Ferris Wheel is turning clockwise as shown, but is speeding up. The acceleration of the seat at point P has component(s) in which direction(s)? Mark ALL that apply
   a. left
   b. right
   c. up
   d. down

34. Aztec performers in Mexico spin around a large pole from ropes that attach at the top and to one leg. If the length of the rope is 20 m, and the angle between the rope and pole is 30 degrees, their speed must be ______ m/s.
   a) 0 to 7
   b) 7 to 8
   c) 8 to 9
   d) 9 to 10
   e) 10 to 11
   f) 11 to 12
   g) more than 12