Your code is:

Put your name here:

Keep this exam **CLOSED** until advised by the instructor.

---

60 minute long closed book exam.

Fill out the bubble sheet: last name, first initial, student number, section number and **code**.

A two-sided 8.5 by 11 handwritten help sheet is allowed.

When done, hand in your **test** and your **bubble sheet**.

Thank you and good luck!

Possibly useful constants:

- g = 9.81 m/s^2
- G = 6.67$\times 10^{-11}$ Nm^2/kg^2
- σ = 5.67 $\times$ 10^{-8} W/(m^{2}K^4)
- R= 0.0821 L*atm/(mol*K) = 8.31 J/(mol*K)

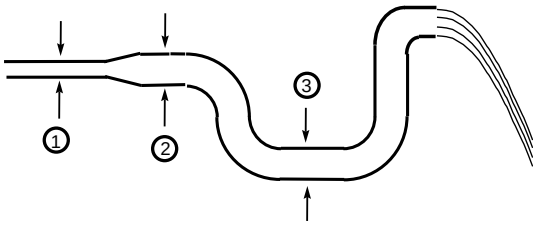
Possibly useful Moments of Inertia:

- Solid homogeneous sphere: $I_{CM} = (2/5)MR^2$
- Thin spherical shell: $I_{CM} = (2/3)MR^2$
- Thin uniform rod, axis perpendicular to length: $I_{CM} = (1/12)ML^2$
- Solid homogeneous cylinder, axis through center of mass and parallel to length: $I_{CM} = (1/2)MR^2$

10 pt A mass of 50 kg is suspended from a steel wire of diameter 1.1 mm and length 0.7 m. How much does the wire stretch in mm? Young's modulus for steel is 2.0 x 10^{11} N/m^2.

1.A◯ 0.979 **B**◯ 1.107 **C**◯ 1.251 **D**◯ 1.413
E◯ 1.597 **F**◯ 1.804 **G**◯ 2.039 **H**◯ 2.304

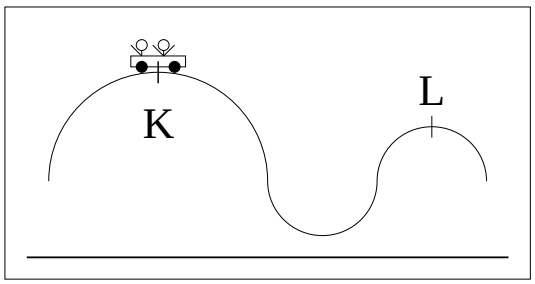
6 pt The side view of a pipe is shown. The pipe diameter increases and then remains constant. P_i is the pressure, and v_i is the speed of a non-viscous incompressible fluid, at locations i = 1,2,3.



▷ v_2 is .... v_3.
2. **A**◯ Greater than **B**◯ Less than
C◯ Equal to

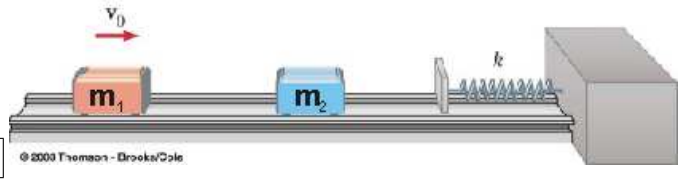
▷ P_2 is .... P_1.
3. **A**◯ Greater than **B**◯ Less than
C◯ Equal to

On a roller coaster ride the total mass of the cart - with passengers included - is 275 kg. Peak **K** is at 48.0 m above the ground, peak **L** is at 23.5 m. The speed of the cart at **K** is 17.8 m/s, at **L** it is 12.4 m/s. (The wheel mechanism on roller coaster carts always keeps the carts safely on the rail.)



9 pt How much energy is lost due to friction between the two peaks?
(in J*)*

4.A◯ 3.45×10^4 **B**◯ 4.04×10^4 **C**◯ 4.72×10^4
D◯ 5.53×10^4 **E**◯ 6.47×10^4 **F**◯ 7.57×10^4
G◯ 8.85×10^4 **H**◯ 1.04×10^5



12 pt

The mass m_1 enters from the left with velocity v_0 and strikes a mass $m_2 > m_1$ which is initially at rest. The collision between the blocks is perfectly elastic. The mass m_2 then compresses the spring an amount x. (positive velocities move to the right)

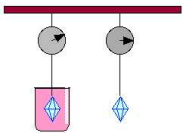
▷ Immediately after the collision, the energy of m_2 is ..... the initial energy of m_1.
5. **A**◯ greater than **B**◯ equal to
C◯ less than

▷ The maximum energy stored in the spring is ..... the initial energy of m_1.
6. **A**◯ greater than **B**◯ equal to
C◯ less than

▷ Immediately after colliding with m_2, the velocity of mass m_1 is ..... zero.
7. **A**◯ greater than **B**◯ equal to
C◯ less than

▷ Immediately after the collision, the momentum of m_2 is ..... the initial momentum of m_1.
8. **A**◯ greater than **B**◯ equal to
C◯ less than

9 pt



A piece of moon rock reads 35.6 grams on a scale when in air, but 19.6 grams in a fluid having a specific gravity of 0.77. What is the density of the moon rock in kg/m^3?

9.A◯ 7.81×10^2 **B**◯ 9.14×10^2 **C**◯ 1.07×10^3
D◯ 1.25×10^3 **E**◯ 1.46×10^3 **F**◯ 1.71×10^3
G◯ 2.00×10^3 **H**◯ 2.35×10^3

12 pt A figure skater is spinning with her arms and one leg extended as far as she can. She then pulls them in tight to her body. As her position contracts,

▷ her angular velocity _____.
10. **A**◯ decreases **B**◯ increases
C◯ remains the same

▷ her moment of inertia _____.
11. **A**◯ decreases **B**◯ increases
C◯ remains the same

▷ her rotational kinetic energy _____.
12. **A**◯ decreases **B**◯ increases
C◯ remains the same

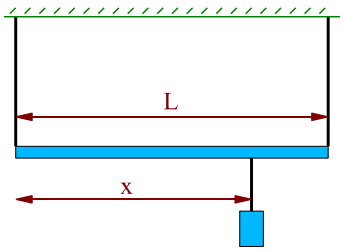
▷ her angular momentum _____.
13. **A**◯ decreases **B**◯ increases
C◯ remains the same

---

6 pt Some curious students hold a rolling race by rolling four items down a steep hill. The four items are a solid homogeneous sphere, a thin spherical shell, a solid homogeneous cylinder and a hoop with all its mass concentrated on the hoop's perimeter. All of the objects have the same mass and start from rest. Assume that the objects roll without slipping and that air resistance and rolling resistance are negligible. For each statement below, select True or False.

▷ All four objects will reach the bottom of the hill at the same time.
14. **A**◯ True **B**◯ False

▷ Upon reaching the bottom of the hill, the hoop will have a larger rotational kinetic energy than any of the other objects will when they reach the bottom of the hill.
15. **A**◯ True **B**◯ False



9 pt
Two wires support a beam of length L=16 as shown in the figure above. A box hangs from a wire which is connected a distance of 12 m from the left edge of the beam. The tension in the left support wire is 600 N and the tension in the right support wire is 800 N. What is the mass of the box? DATA: acceleration of gravity=9.80 m/s^2 *(in* `kg`*)*

16.**A**◯ 29.8 **B**◯ 34.9 **C**◯ 40.8 **D**◯ 47.8
E◯ 55.9 **F**◯ 65.4 **G**◯ 76.5 **H**◯ 89.5

---

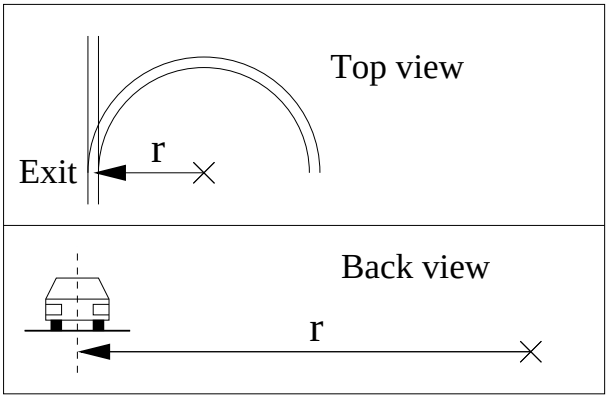
9 pt Identify the statements as being either True or False.

▷ Consider two planets orbiting a star. If one planet has two times the period of another, it must also have three times the average orbital distance.
17. **A**◯ True **B**◯ False

▷ If two planets have the same mass, but the second has four times the gravity, the second planet must also have half the radius.
18. **A**◯ True **B**◯ False

▷ An object moving in a circle with constant speed is accelerating.
19. **A**◯ True **B**◯ False

The radius of curvature of a highway exit is r = 62.5 m. The surface of the exit road is horizontal, not banked. (See figure.)

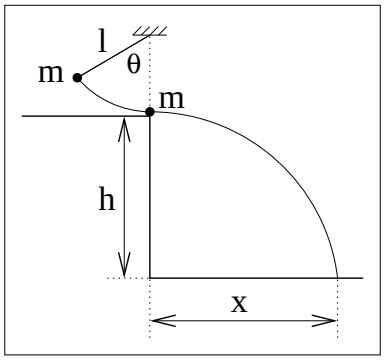


9 pt If the static friction between the tires and the surface of the road is $\mu_s = 0.575$, then what is the maximum speed at which the car can exit the highway safely without sliding? *(in* `m/s`*)*

20.**A**◯ 9.02 **B**◯ 1.02×10^1 **C**◯ 1.15×10^1
D◯ 1.30×10^1 **E**◯ 1.47×10^1 **F**◯ 1.66×10^1
G◯ 1.88×10^1 **H**◯ 2.12×10^1

---

9 pt A small metal ball with a mass of m = 62.2 g is attached to a string of length l = 1.41 m. It is held at an angle of $\theta = 47.7°$ with respect to the vertical.



The ball is then released. When the rope is vertical, the ball collides head-on and perfectly elastically with an identical ball originally at rest. This second ball flies off with a horizontal initial velocity from a height of h = 3.31 m, and then later it hits the ground. At what distance x will the ball land?
(in `m`*)*

21.A◯ 6.48×10^{-1} **B**◯ 8.10×10^{-1} **C**◯ 1.01
D◯ 1.26 **E**◯ 1.58 **F**◯ 1.98
G◯ 2.47 **H**◯ 3.09