

Form 1

Midterm II November 8, 1999

Name:

Useful constants: $\rho_{\text{water}}=1000 \text{ kg/m}^3$, $G=6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$, $N_A=6.02 \times 10^{23}$,
 $R=8.31 \text{ J/(mol K)}$, $k = 1.38 \times 10^{-23} \text{ J/K}$, $M_e=5.98 \times 10^{24} \text{ kg}$, $g=9.8 \text{ m/s}^2$.

1. A billiard ball of mass $m_1=100 \text{ g}$ has a one-dimensional collision with another billiard ball of mass $m_2=200 \text{ g}$ which is at rest. After the collision ball #1 goes backward with a speed of 10 cm/s , while ball #2 moves forward with a speed of 15 cm/s . What was the initial speed of ball #1? (Use momentum conservation)

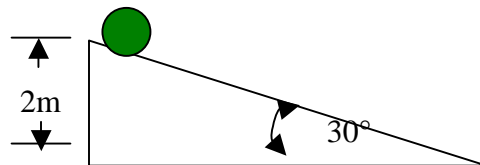
- A) 10 cm/s
- B) 15 cm/s
- C) 20 cm/s
- D) 25 cm/s
- E) 30 cm/s

2. A new planet, "Vulcan", has been found in the solar system. If its period (the time it takes to make one orbit around the sun) is 27 years, how far (in earth radii) is it from the sun? You may assume that all orbits are circular.

- A) 3
- B) 9
- C) 27
- D) 81
- E) 729

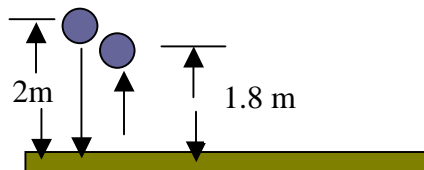
3. A solid sphere ($I = \frac{2}{5} MR^2$) with $M = 200\text{g}$, $R=5\text{cm}$, rolls without slipping down an inclined plane of height $h = 2\text{m}$, making an angle of 30° with the horizontal. If it starts from rest, what is the speed of the center of mass at the bottom of the plane?

- A) 6.3 m/s
- B) 5.3 m/s
- C) 7.5 m/s
- D) 8.9 m/s
- E) 9.9 m/s



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4. A man of mass 60 kg and density, $\rho_m = 950 \text{ kg/m}^3$, dives into the ocean ($\rho_o = 1070 \text{ kg/m}^3$). What buoyant force does he experience at the moment when exactly 1/2 of his body is under water?
- A) 663 N
B) 68 N
C) 523 N
D) 389 N
E) 331 N
5. A 50-kg satellite is put into a circular orbit around the earth with a period of 48 hours. What is the kinetic energy of this satellite in Joules? $M_e = 6 \times 10^{24} \text{ kg}$ and $R_e = 6400 \text{ km}$.
- A) $3.48 \times 10^{10} \text{ J}$
B) $1.95 \times 10^5 \text{ J}$
C) $5.25 \times 10^6 \text{ J}$
D) $1.49 \times 10^8 \text{ J}$
E) $8.35 \times 10^{15} \text{ J}$
6. A 0.5 kg ball is dropped to the floor from a height of 2m. If it bounces back to a height of 1.8 m, what is the magnitude of the change in its momentum (in kg m/s)?

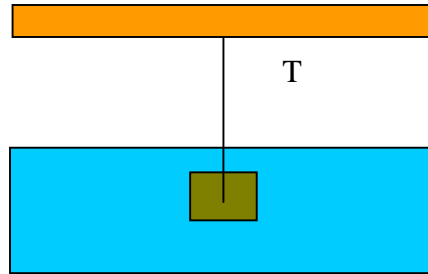


- A) 0.31
B) 122.1
C) 6.1
D) 3.1
E) 37.3

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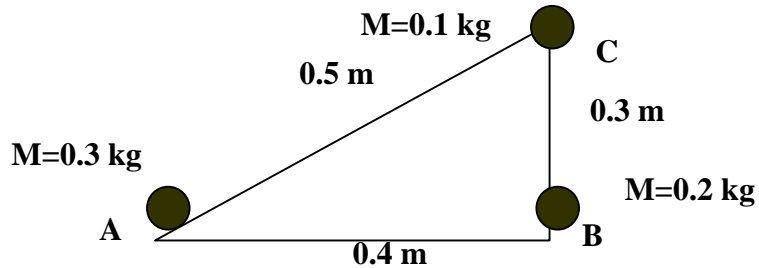
7. A metal block with mass 0.5 kg and density $8 \times 10^3 \text{ kg/m}^3$ is suspended from a string in a tank of water ($\rho = 10^3 \text{ kg/m}^3$). What is the tension in the string?

- A) 42.9 N
- B) 0.429 N
- C) 4.29 N
- D) 429 N
- E) 43.8 N



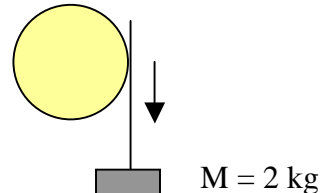
8. Three massive objects A, B and C are connected by massless rods as shown in the diagram. If the whole system rotates about an axis perpendicular to the page and passing through the center of object A at an angular velocity $\omega = 4 \text{ rad/s}$, what is the total kinetic energy of the system. You may ignore the contribution of object A.

- A) 4.56 J
- B) 45.6 J
- C) 0.456 J
- D) 456 J
- E) 9.2 J



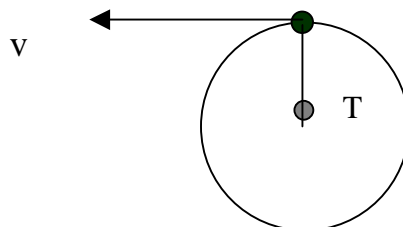
9. A mass of 2 kg hangs vertically from a string wrapped around a solid cylinder of radius 1 m and mass 2 kg . If the cylinder is free to rotate around its center of mass, what is the magnitude of the acceleration of the mass in units of g , the acceleration of gravity? ($I_{\text{Cyl}} = 1/2 MR^2$)

- A) g
- B) $g/2$
- C) $g/3$
- D) $2g/3$
- E) $3g/4$



10. A ball of mass $m = 2.0 \text{ kg}$ is attached to a string of length $L = 1.0 \text{ m}$ and whirled around on a smooth horizontal table. If the string breaks when the tension on it exceeds 200 N , what will be the speed of the ball at the instant the string snaps?

- A) 1 m/s
- B) 2 m/s
- C) 5 m/s
- D) 10 m/s
- E) 20 m/s



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11. An artery initially has a diameter of 0.5 cm and is capable of carrying 1 liter (10^{-3} m^3) of blood per minute. Over the years this diameter is reduced to 0.4 cm. Assuming the pressure across the artery does not change, what is the new flow rate the artery can sustain? (Use Poiseuille's Law)
- A) 0.64 liters/min
 - B) 0.41 liters/min
 - C) 0.25 liters/min
 - D) 0.0625 liters/min
 - E) 0.041 liters/min
12. A sealed container of fixed volume 20 liters is initially filled with an ideal gas at 50°C at a pressure of 6000 Pa. If the gas is now heated so that the pressure in the container rises to 8000 Pa, what is the new temperature?
- A) -31°C
 - B) 38°C
 - C) 67°C
 - D) 158°C
 - E) 431°C