Practice Final

Instructions:

This exam consists of 6 short answer problems and 7 multiple choice questions and 1 visualization exercise.

Show your work on the test for the short answer problems. You must show your work to get credit for the short answer problems. Each problem is worth the same amount. Report answers in SI units unless otherwise indicated.

You do not need to show any work for the multiple choice problems, however, mark your answers in the boxes at the end of the section. There are no penalties for guessing, so answer every question.

Test Aids:

A scientific calculator may be used. Graphing calculators may not.

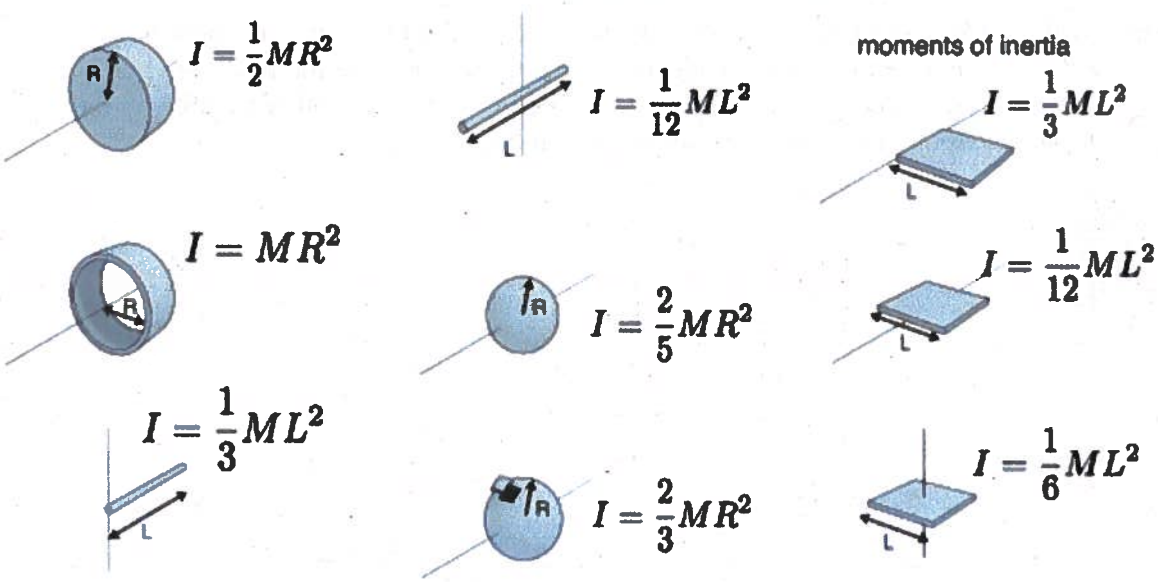


Table of physical properties

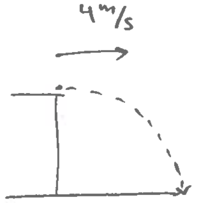
Specific Heat of liquid water: 4186 J/(kg C)
Specific Heat of ice: 2000 J/(kg C)
Latent Heat of Fusion of water: 334 kJ/kg
Latent Heat of Vaporization of water: 2257 kJ/kg
Density of Water: 1000 kg/m^3

Academic Integrity:

Academic dishonesty is prohibited in The City University of New York. Penalties for academic dishonesty include academic sanctions, such as failing or otherwise reduced grades, and/or disciplinary sanctions, including suspension or expulsion.

Short Answer

1. A ball is thrown horizontally from the edge of a building at 4 m/s. If it takes 5 seconds to land a) how tall is the building ? b) how far from the edge will it land and c) what will its speed be when it hits the ground.



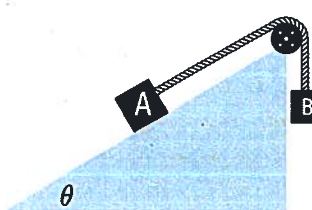
a)
$$y = y_0 + v_{0y} t - \frac{1}{2} g t^2$$
$$0 = h + 0(t) - \frac{1}{2} g t^2$$
$$h = \frac{1}{2} g t^2 = \frac{1}{2}(9.8)(5)^2 = 122.5 \text{ m}$$

b)
$$x = \underbrace{x_0}_{0} + v_{0x} t + \underbrace{\frac{1}{2} a_x t^2}_{0}$$
$$x = v_{0x} t = 4 \times 5 = 20 \text{ m}$$

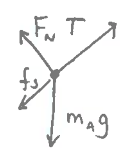
c)
$$v = \sqrt{v_x^2 + v_y^2} = 49.163 \approx 49.2 \text{ m/s}$$
v_x: 4 m/s

$$v_y = v_0 - gt = 0 - 9.8(5) = 49$$

2. Here are two blocks. If the coefficient of static friction between block A and the ramp is μ_s, what is the smallest mass that block B can be in order to cause the blocks to accelerate? The rope and pulley are both massless. First, express your answer in an expression that gives the m_B in terms of the other variables in the setup. Then, use: $\mu_s = 0.4$, $m_A = 3kg$, and $\theta = 30°$ to get an actual number.



[A]



[B]

grav: component of gravity parallel/Perp to ramp

$$F_{G\parallel} = m_A g \sin\theta$$
$$F_{G\perp} = m_A g \cos\theta$$

static friction:
$$f_s^{MAX} = \mu_s F_N = \mu_s m_A g \cos\theta$$

if $m_B g > T$, then mass B will accelerate down.

since T is the same,

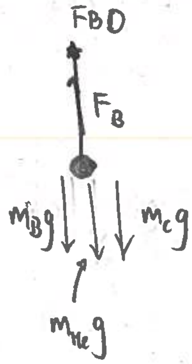
$T > f_s + mg\sin\theta$ will cause acceleration, thus

$$m_B g > f_s + m_A g \sin\theta$$
$$> \mu_s m_A g \cos\theta + m_A g \sin\theta$$
$$m_B > m_A(\mu_s \cos\theta + \sin\theta)$$

$m_B > 2.54$ kg will cause an acceleration.

3. Estimate, using math and physics, how many helium filled balloons it would take to lift an average cat off the ground. You'll have to make some assumptions but just try to be reasonable. (The density of helium is 0.179 kg/m³ and the density of air is 1.2 kg/m³)

neutral buoyancy.



$$\Sigma F_y = F_B - m_B g - m_c g - m_{He} g = 0$$

make some estimates:

$R_{balloon} = 0.15$ m

mass cat $= 5$ kg

mass balloon $= .005$ kg

$$F_B = \rho_{AIR} V_B g$$

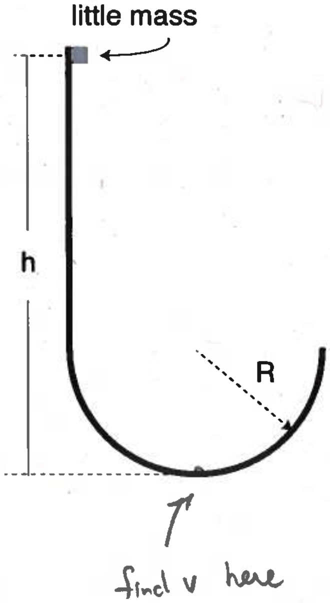
$$M_{He} = \rho_{He} V_B$$

$$\Sigma F_y = \underbrace{\rho_{AIR} V_B g - m_B g - \rho_{He} V_B g}_{\text{multiply these by \# of Balloons (N)}} - m_c g = 0$$

$$N[\rho_{AIR} V_B - m_B - \rho_{He} V_B] - m_c = 0 \quad \text{solve for } N$$

$$N = \frac{m_c}{V_B(\rho_{AIR} - \rho_{He}) - m_B} = \frac{5}{4/3 \pi R^3 (1.2 - 0.179) - .005} \approx 530 \text{ balloons (about)}$$

4. A small mass m is dropped from a height h as shown. What will the normal force acting on the mass be, when it is at the very bottom of the bowl (with radius R)? Express F_N in terms of m, g, and h.



Conservation of Energy:

$$\Delta U = -\Delta KE$$

$$0 - mgh = -\frac{1}{2}mv^2 + 0$$

$$\therefore v = \sqrt{2gh}$$

at bottom

centripetal acceleration

$$\Sigma F_y = F_N - mg = ma = m\frac{v^2}{R}$$

$$\therefore F_N = m\left(\frac{v^2}{R} + g\right) \quad \& \quad v^2 = 2gh$$

$$= m\left(\frac{2gh}{R} + g\right)$$

$$= mg\left(\frac{2h}{R} + 1\right)$$

5. If I put 400 grams of -20° C ice in 2 liters of really hot tea (i.e 100 °C), what will the temperature be when the system reaches equilibrium? (use the table of materials information on the front cover)

$Q_{ice} = -Q_{WATER}$ → call $T_1 = -20°C$

$=$ $T_2 = 100°C$

$T_3 =$ final Equilibrium temp

$$m_{ice} C_{ice} (0 - T_1) + m_{ice} L_F + m_{ice} C_{water} (T_3 - 0) = -m_w c_w (T_3 - T_2)$$

warm up the ice

melt the ice

warm up the new water that was the ice

cool the existing tea.

Solve this for T_3

$$m_{ice} (L_F - C_{ice} T_1) = -m_{ice} C_w T_3 - m_w c_w T_3 + m_w c_w T_2$$

$$m_{ice} (L_F - C_{ice} T_1) - m_w C_w T_2 = -T_3 (m_{ice} C_w + m_w C_w)$$

$$T_3 = -\left(\frac{m_{ice} (L_F - C_{ice} T_1) - m_w c_w T_2}{m_{ice} C_w + m_w C_w} \right) = \frac{0.4 (334{,}000 - 2000 \times (-20)) - 2\,kg \times 4186 \times 100}{.4 \times 4186 + 2\,kg\ 4186}$$

$= +68.44°C$

will be the equilibrium temp.

Multiple Choice

7. Two people of very unequal weight are sitting still in similar roller chairs. They both push off each other and proceed to move in opposite directions. Which of the following is true?

$P_i = P_f$, cons. of momentum

A. The total mechanical energy is the same before and after they do the pushing.
B. The magnitude of momentum of the big person is the same as the magnitude of momentum of the smaller person after the pushing.
C. The center of mass of the two-person system moves after the pushing.
D. The two people have equal but opposite acceleration vectors during the pushing.

8. A steel marble and a small feather are dropped simultaneously in a vacuum chamber. After falling a distance of 1 meter, they both would have the same:

A. Momentum
B. Kinetic Energy
C. Speed
D. change in potential energy

9. There are several ways to quantify the units of Power. Which of the following are possibilities:

I. Watt
II. Joule per second
III. Kilowatt-hour

A. I only
B. II only
C. III only
D. I and II only
E. II and III only
F. I, II, and III

10. If you apply heat to a metal rod, the change in length of the rod does not depend on:

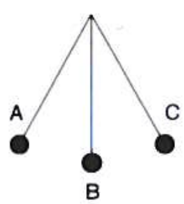
A. The length of the rod
B. The type of metal
C. The cross-sectional area of the rod
D. The amount of heat applied

11.

12. A not very bright cat is running straight towards a brick wall. When the collision occurs which of the following is true?

A. The acceleration of the cat is equal to the acceleration of the wall.
B. The force of the cat on the wall is less than the force of the wall on the cat.
C. The force of the cat on the wall is greater than the force of the wall on the cat.
D. The force of the cat on the wall is equal to the force of the wall on the cat.

13. An object of mass m is attached to string, as shown. When it is released from point A, the object oscillates between points A and C. Which statement about the system consisting of the pendulum and the Earth is correct?



A. The gravitational potential energy is greatest at points A & C.
B. The kinetic energy of *m* is greatest at point B.
C. The momentum of mass *m* is changing the fastest at points A and C
D. Only A and B are true
E. The statements A, B, and C are correct.

Multiple Choice Answers

Enter your answers in these boxes.

7	8	9	10	11	12	13

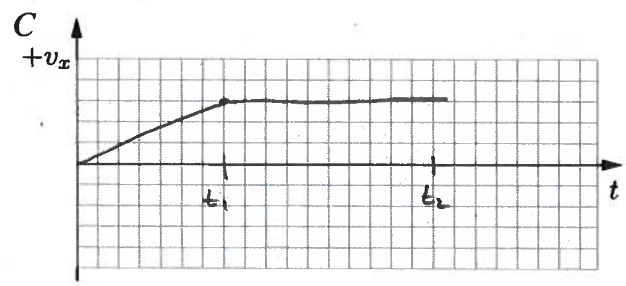
14. On the 5 axes below, sketch plots that would describe the given situation.

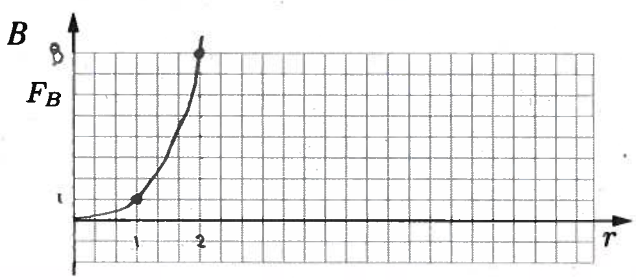
B. The buoyancy force on an air filled balloon underwater as a function of the radius of the balloon.

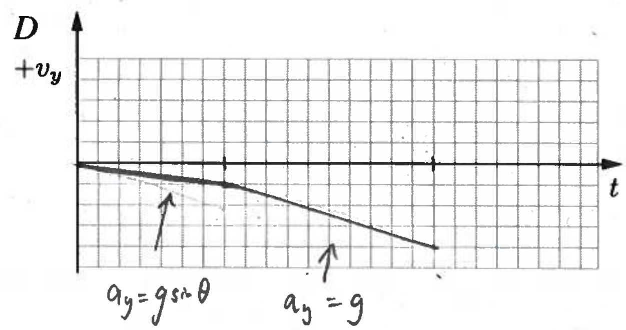
At $t = 0$, a ball begins rolling down a slightly slanted roof, until it reaches the edge at $t = t_1$, then falls to the ground and lands at $t = t_2$.

C. Draw the ball's x velocity as a function of time

D. Sketch the ball's y velocity as a function of time







$F_B = V \times \rho \times g$

$= \frac{4}{3}\pi R^3 \times \rho \times g$

$\therefore F_B \sim R^3$