Physics P221
Final Exam

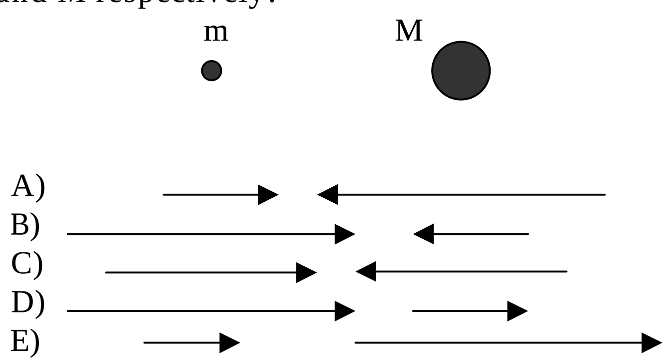
D. Baxter and R. Heinz

December 18, 1998

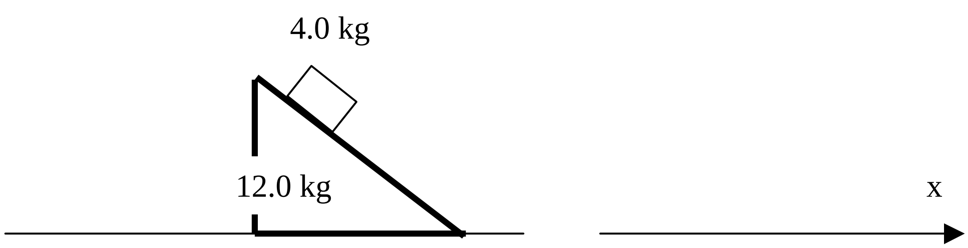
Student Name_____________________**Student ID**_______________________

Each part of each problem is worth 6 points. **Show your work for all problems.** You may consult five sheets of personal notes and you may use the appendices in our HR&W text.

1). A moon of mass m is near a planet of mass M and the two bodies interact gravitationally. M is much larger than m. Which set of arrows best represents the forces on m and M respectively?



2). A large triangular wedge with a mass of 12.0 kg rests on a frictionless horizontal surface as shown. A block of mass 4.0 kg is released from rest on the stationary wedge, which is rough. A short time after the block is released, the wedge is found to be moving to the left with a speed of 2.0 m / s. What is the x-component of the block's velocity at this time?



A) 12.0 m / s
B) 6.0 m / s
C) 4.0 m / s
D) 2.0 m / s
E) 0.5 m / s

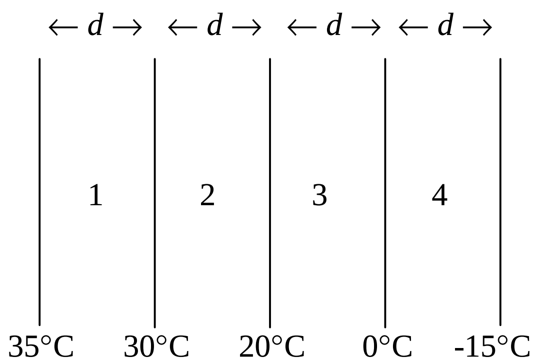
3). In 1950s Life Magazine published a sequence of photographs showing the size of the fireball associated with an early nuclear bomb test. A physicist named G.I. Taylor deduced the approximate energy of the bomb (a closely held national secret at the time) by realizing that the fireball radius could depend only on the energy of the bomb (E), the time since its ignition (t) and the density of the air (ρ). Which of the expressions below is the correct relationship between the radius (r) and E, ρ and t (in all cases C is a dimensionless constant of order 1) ? SHOW YOUR WORK

A) $r = CE(\rho t)^{1/2}$
B) $r = CE(\rho/t)^{1/3}$
C) $r = C(E\,\rho/t^2)^{1/4}$
D) $r = C(E\,t^2/\rho)^{1/5}$
E) $r = C(E^2\,t^3/\rho)^{1/6}$

4). An ice skater with rotational inertia I_0 is spinning with angular speed ω. She pulls her arms in, decreasing her rotational inertia to $I_0/3$. Her angular speed is now....

A) $3\,\omega$
B) $1.732\,\omega$
C) ω
D) $\omega/1.732$
E) $\omega/3$

5). The diagram shows four slabs of different materials with equal thickness, placed side by side. Heat flows from left to right and the steady-state temperatures of the interfaces are given. Rank the materials according to their thermal conductivities, smallest to largest.



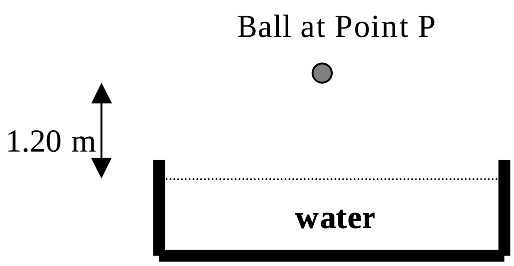
A) 1, 2, 3, 4
B) 2, 1, 3, 4
C) 3, 4, 1, 2
D) 3, 4, 2, 1
E) 4, 3, 2, 1

6). On a stormy day the wind is blowing across the outside of a 2.00 m by 4.00 m window in an office building at a speed of 30.0 m / s. What is the magnitude of the net force acting on the window assuming that the pressure inside the building is adjusted to be equal to that on the outside on a calm day?

$(\rho_{air} = 1.23\ \mathrm{kg/m^3})$

A) 2.10×10^4 N
B) 4.43×10^3 N
C) 3.56×10^3 N
D) 1.05×10^3 N
E) 6.21×10^2 N

7). A solid spherical iron ball is dropped into a swimming pool from point P, a height of 1.20 m above the water, and hits the **bottom of the pool** 1.50 s later. It hits the water at the **top of the pool** with a speed *s*, then sinks to the **bottom of the pool** at a constant speed of *s*.



A) What is *s*?

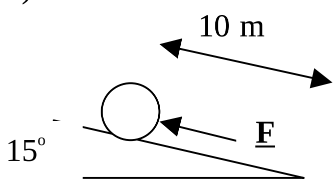
B) How deep is the pool?

C) What is the average speed of the ball while it is moving?

D) What is the buoyancy force on the ball as it rests on the bottom? The density of iron is 7900 kg/m^3, the density of water is 1000.0 kg/m^3, and the ball radius is 6.00 cm.

E) What is the coefficient of drag for the ball in water?

8).



A worker rolls an oil drum up at 15° incline. At a particular instant in time he stops and holds the drum in place by applying a force parallel to the incline and directed through the center of the drum as shown in the figure. You may assume that the drum is a **uniform** cylinder of mass 100 kg and radius 0.35 m. The coefficient of friction between the drum and the incline is $\mu_s = 0.45$.

A) Draw a free body diagram showing all forces acting on the oil drum when it is stationary as described above. (Note: since various forces act on different parts of the drum, do not treat it as a point object.)

B) What is the magnitude of the force the worker is applying?

C) What is the magnitude of the static friction force acting between the drum and the incline while the drum is held in place by the worker?

D) The worker gets distracted and lets go of the drum which subsequently rolls without slipping down the incline. How fast is it travelling when it reaches the bottom of the incline, at which time the center of the drum is 10.0 m $\times$ sin(15°) lower ? (I_{drum} = 1/2 MR^2)

9A). A machinist uses a stone grinding wheel to sharpen a drill. During this procedure the temperature of the drill is increased from 25.0°C to 40.0°C. The drill has a mass of 50.0 g and is made of steel (c_p= 0.440 J/g·K). Neglecting any temperature rise in the grinding wheel or the small pieces of steel removed by the wheel from the drill bit, how much energy is dissipated as thermal energy in the drill by the frictional force between the grinding wheel and the drill?

B) After sharpening the drill, the machinist dunks it into a small, insulated, cup containing 75.0 g of water, which is initially at 25.0°C. Neglecting any exchange of heat with the outside world, what will be the final temperature of the water (and the drill) after equilibrium is reestablished? (recall c_{water} = 4.186 J/g·K)

10). The speed of sound in air at standard pressure and a temperature of 20.0°C is 343 m / s.

A) An organ pipe is designed to emit sound at 400.0 Hz for its fundamental mode. What is the wavelength of the sound emitted by this organ pipe when it is in tune?

B) The organ pipe from Part A is essentially closed at one end. How long is the pipe?

C) What is the frequency of the lowest harmonic frequency above the fundamental for the organ pipe of Part B).

D). An organ tuner tests this same pipe against a 400.0 Hz tuning fork and hears a beat maximum every 2.0 seconds. He then finds that he can increase the beat period to 10 seconds by sticking a small bit of wax on the tuning fork. What is the actual frequency of the organ pipe?

E). Assume that a listener at a distance of 50 m is far enough away for the organ pipe to be treated as a point source. The listener hears the pipe at a sound intensity level of 80 dB. What is the rate at which energy is emitted by the organ pipe as sound waves? (Recall that the threshold for human hearing is 10^{-12} W / m^2.)

11A). Estimate the magnitude of work done by gravity during the upward motion of a typical not-overly-athletic adult (say Professor Baxter or Heinz) while he jumps vertically from a stationary, crouched, position. Make whatever assumption you think reasonable for the values of the relevant physical quantities, but be sure to clearly identify the appropriate physical law (equation) used to convert those assumed values into your energy estimate. Your answer need only be within a factor of 20 of our estimate.

B). Based on your estimated energy from Part A), estimate the radius of the largest planet from which that typical adult could jump to leave and never return. You may ignore practical matters such as the need for him to wear a space suit, as well as the presence of any other nearby planets.

Score

1-6	(36)	______
7	(30)	______
8	(24)	______
9	(12)	______
10	(30)	______
11	(12)	______
Total	(144)	______