PHYSICS 131 FINAL EXAM 8 May 2001

INSTRUCTIONS: Write your name on the front of the blue exam booklet. The exam is closed book, and you may have only a pen/pencil and a calculator (no stored equations or programs and no graphing). Show all of your work in the blue book. For problems II−V, an answer alone is worth very little credit, even if it is correct − so show how you get it.

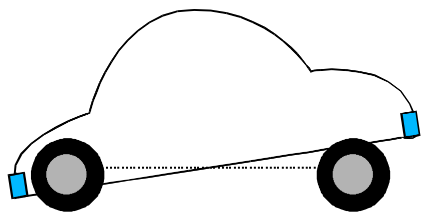
Suggestions: Draw a diagram when possible, circle or box your final answers, and cross out parts which you do not want us to consider.

Graded exams will be available for pickup on Thursday afternoon from your *official* lecturer. Solutions will then also be posted on class bulletin board and on website. All requests for regrades must be made by 5:00pm on Friday.

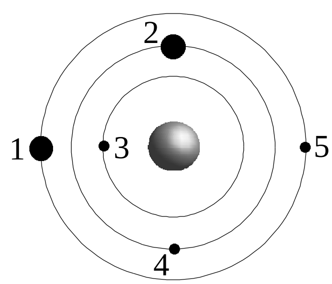
I. *Multiple Choice Questions* (4 points each).

1. A gorilla jumps onto the trunk of your new VW Beetle (of mass *m*), squashing the back end of the car nearly to the ground. Then, he just as suddenly jumps off. If your car has four shock absorbers with the same spring constant *k*, and the two in the back were equally compressed by the gorilla, what is the angular frequency of oscillation (ω) of the car after the gorilla jumps off?

A) $\sqrt{k/m}$
B) $2\sqrt{k/m}$
C) $4\sqrt{k/m}$
D) $\sqrt{2k/m}$
E) $3\sqrt{k/m}$



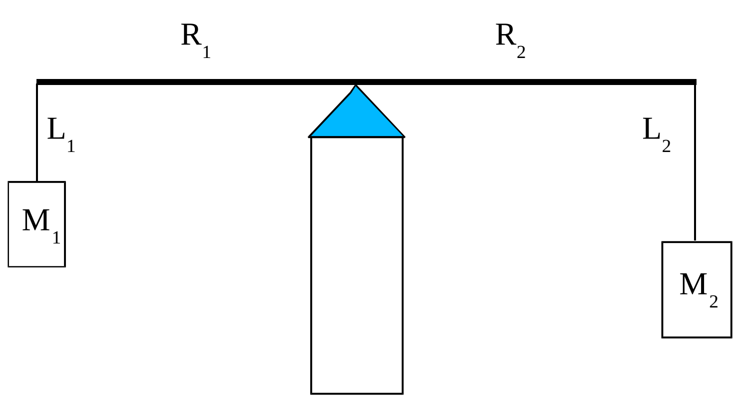
2. Of the satellites shown revolving around the earth, which is the one with the greatest tangential speed. (Assume the masses such that $m_1 = m_2 > m_3 = m_4 = m_5$.)



A) 1 B) 2 C) 3 D) 4 E) 5

3. The horizontal bar in the figure will remain horizontal if

A) $L_1 = L_2$ and $R_1 = R_2$
B) $L_1 = L_2$ and $M_1 = M_2$
C) $R_1 = R_2$ and $M_1 = M_2$
D) $L_1M_1 = L_2M_2$
E) $R_1L_1 = R_2L_2$

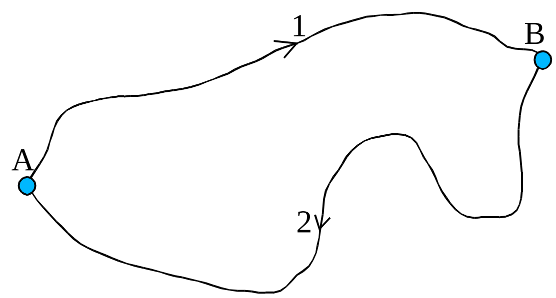


4. Two identical cars in a "Bumper Cars" carnival ride travel towards each other with equal velocities. They collide head−on in a collision that is between inelastic and elastic, *i.e.*, some energy is lost. Just after the collision, their velocities are

A) zero.
B) equal to their original velocities.
C) equal in magnitude but opposite in direction to their original velocities.
D) less in magnitude but in the same direction as their original velocities.
E) less in magnitude and opposite in direction to their original velocities.

5. Consider a process in which a particle goes from A to B along path 1, and from B back to A along path 2, as shown in the figure. Let W_1 equal the work done in moving the particle from A to B along path 1, and W_2 equal the work done in moving the particle from B to A along path 2. If only conservative forces are acting, then

A) $W_1 > W_2$
B) $W_1 < W_2$
C) $W_1 + W_2 > 0$
D) $W_1 + W_2 < 0$
E) $W_1 + W_2 = 0$
F) $W_1 - W_2 = 0$



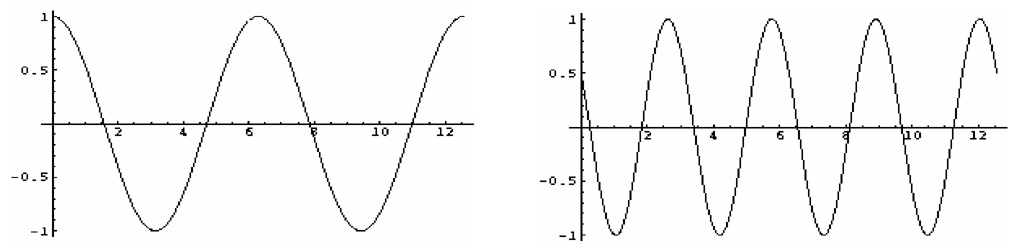
6. A mass is sitting at $x=0$ and is given a <u>small</u> push. For which of the following potential energy functions will the mass *NOT* undergo simple harmonic oscillations about $x=0$? (In each of these, b is some numerical constant.)

A) $U(x) = bx^2$ B) $U(x)= \sin(bx)$ C) $U(x) = \cos(bx)$
D) $U(x) = e^x + e^{-x}$ E) $U(x) = x^2 + bx^3$

7. A car uses 20 gallons of gas travelling for 10 hours at 50 mph on flat roads. Ignoring all frictional effects and engine inefficiencies <u>except</u> <u>drag</u> ($F=bv^2$ with b some constant), how much gas will the car need to travel for 10 hours at 70 mph on flat roads? (Assume that a gallon of gas can always provide the same amount of energy.)

A) 10 gallons B) 28 gallons C) 39 gallons
D) 55 gallons E) 77 gallons

8. Look at the two harmonic waves in the figure. If the left wave is described by the wavefunction *y(x) = A cos(kx)*, then which of the following wavefunctions best describes the right wave?

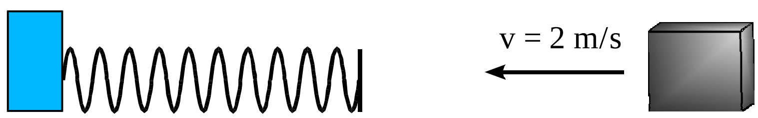


A) *A cos(2kx)* B) *2A cos(kx + π/3)* C) *A cos(2kx + π/3)*
D) *A cos(kx/2 + π/3)* E) *A cos(kx − π/3)* F) *A cos(kx/2 − π/3)*

Problems:

II. A 3 kg mass slides sideways on a frictionless surface with a velocity of 2 m/s and collides with a fixed massless spring of spring constant *k* = 60 N/m.

A) What is the maximum compression of the spring?



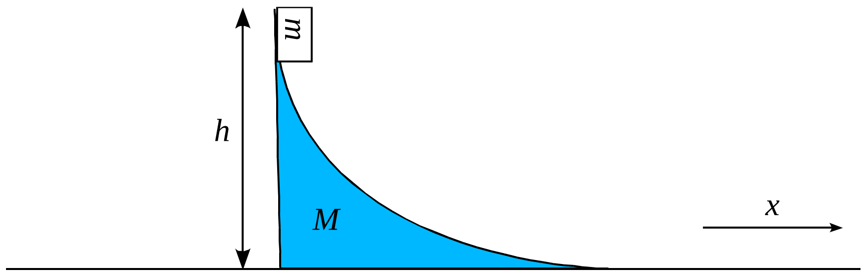
The mass is very sticky and stays stuck to the spring, so that the system now undergoes simple harmonic motion.

B) What is the frequency (*f*, not ω) of oscillation?

C) What is the amplitude of the motion?

D) How long does it take to go from the equilibrium position to the maximum extension?

III. A block of mass m is released from rest and slides along a frictionless crescent−shaped wedge of mass M. The wedge is sitting on a frictionless surface. The center−of−mass of the block begins at a height h above the surface. You can ignore the finite size of the block for this problem.



A) Are any components of momentum conserved in this problem? If so, list them and give reasons why they are conserved.

B) Find the final velocity (magnitude and direction) V of the wedge and the final velocity U of the block, assuming that the block will move in the positive x direction.

Now, assume that there is friction between the block and the wedge.

C) Are any components of momentum conserved now? Why or why not?

IV. On Saturday, the horse Monarchos won the Kentucky Derby with a near record time of of 1 minute, 59.8 seconds (119.8 seconds). In this time, he covered a distance of 1.25 miles (2011 m). Assume Monarchos has a mass of 350 kg (about 750 lbs.).

A) Calculate Monarchos' average speed over the course of the race.

B) Assuming constant acceleration, what is Monarchos' speed at the end of the race?

C) One horsepower is equal to 746 Watts. If Monarchos is able to produce one horsepower for 119.8 seconds, how fast would he be travelling at the end of the race?

D) Assume a horse generates some constant power P when it runs. Is its acceleration constant? Why or why not? (Hint: remember the definition of power, $P=Fv$.)

V. Several billion years from now, our sun will begin the last stages of its life−cycle. As a first step, it will suddenly expand into a red giant star. The sun today has a radius $R_S = 7.0 \times 10^8$ m, a rotational period T=25.3 days and a mass $M_S = 2.0 \times 10^{30}$ kg. As a red−giant, it will have a radius of about $R_{RG} = 1.0 \times 10^{11}$ m but unchanged mass.

A) What is the sun's angular momentum today? Assume that the sun's density is constant throughout its volume and that it rotates as a rigid ball.
(Hint: I(ball) = $(2/5)\, MR^2$.)

B) Assuming that the density of a red giant is also constant throughout its volume, calculate the period of rotation of the red giant.

After living as a red giant for a billion years or so, the sun will suddenly explode. All the matter in the outer 25% (radius > 7.5×10^{10} m) of the red giant will be blown into space and whatever remains will shrink down into a white dwarf of radius $R_{WD} = 6.0 \times 10^6$ m and mass $M_{WD} = 8.4 \times 10^{29}$ kg.

C) What is the angular momentum of the red giant immediately after the explosion, but before it has shrunk down to a white dwarf?

D) What is the rotational period of the white dwarf, assuming constant density inside its volume?

E) What is the tangential velocity of the material on the outer edge of the white dwarf's equator?

VI. Referring back to the last problem, you land your spaceship on the surface of the white dwarf to study it. *(Note: you do not have to do the last problem to do this one − just use $R_{WD} = 6.0 \times 10^6$ m and $M_{WD} = 8.4 \times 10^{29}$ kg. Also, ignore the white dwarf's rotation for this problem.)*

A) If you dig your shovel into the surface of the white dwarf and scoop up 1 cm^3 of its material, what would its mass be?

B) How much would that 1 cm^3 of material weigh if you tried to pick it up off the surface of the white dwarf?

C) To escape from the surface of the white dwarf, you have brought along a big cannon. At what speed would it need to shoot you out in order for you to escape from the white dwarf's gravitational pull? (Assume that it is shooting you straight up from the surface.)