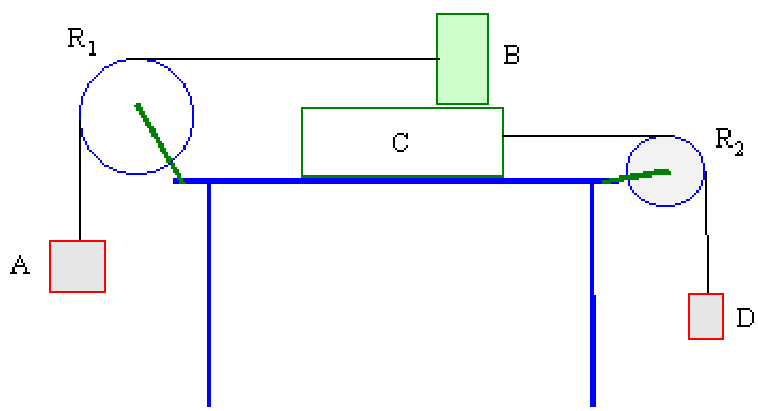
Final Examination

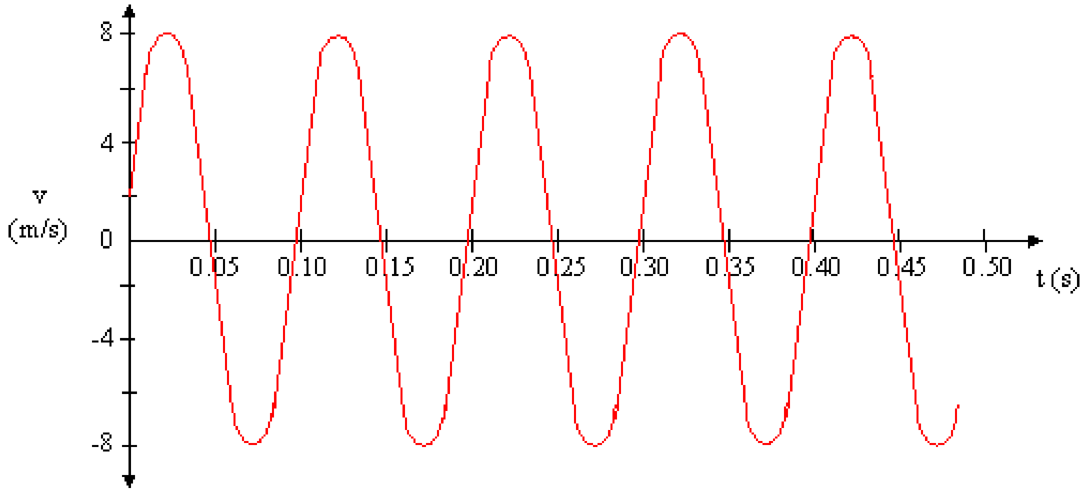
Physics 1120

17 December 1999

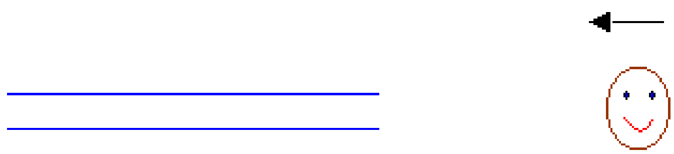
1. Two pairs of blocks are connected over pulleys as shown in the diagram below. Pulley 1, a solid disk, has a mass M_1 and inner radius R_1. Pulley 2, also a solid disk, has mass M_2 and a radius R_2. Block A has a mass M_A, block B M_B, block C M_C, and block D M_D. The strings do not slip. The coefficients of friction between blocks C and D are μ_s and μ_k. The table is frictionless. Blocks A and D are held motionless, then released at the same time and allowed to fall. Derive the set of equations that will determine the acceleration of each set of blocks.



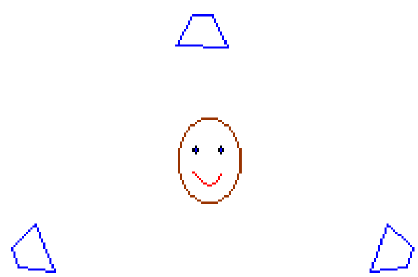
2. A 4.00 kg mass attached to a spring is oscillating back and forth on a frictionless table. A plot of the mass's velocity (**NOT** position) is shown in the diagram below.
(a) What is the period and angular frequency of the motion?
(b) What are the maximum velocity and the maximum displacement A of the block?
(c) What is the possible values of the phase constant that lie between 0 and $+2\pi$?
(d) If the block has a negative displacement at t = 0, write equations for v(t) and x(t).
(e) What is the spring constant?
(f) What is the total energy of the spring and mass?



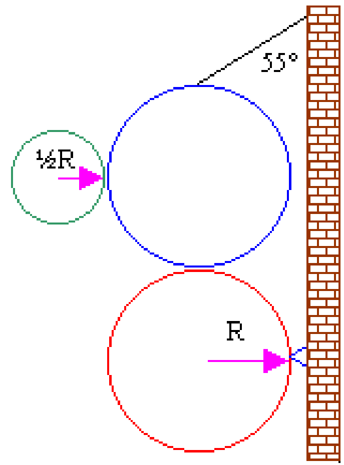
3. (a) A tube open at both ends is vibrating in the 3rd harmonic. A student approaching the tube at 10.0 m/s hears the frequency of the tube as 450 Hz. What is the length of the tube? Sketch the standing wave in the tube. The speed of sound in air is 340 m/s.



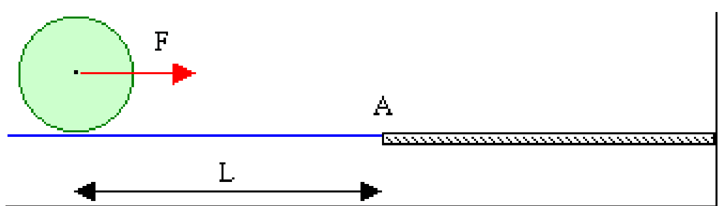
(b) A person is in a room where the background sound level is 55 dB. He is equidistant from three identical stereo speakers. When one speaker is on, the sound level reaches 67 dB. What will the sound level be when all three speakers are turned on?



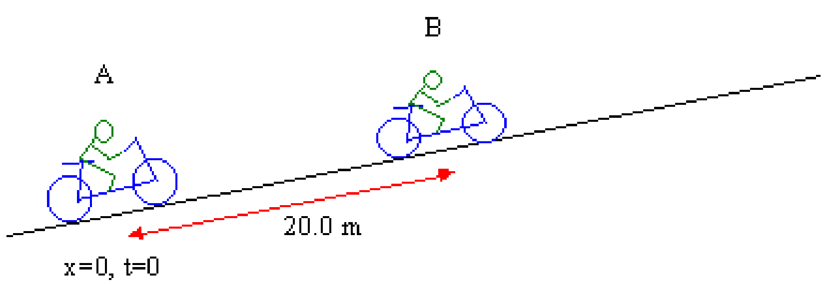
4. A weird sign is hanging from the side of a building as shown in the diagram below. The radius of the big circles is R. The radius of the small circle is ½R. The sign is uniform and has a mass of 270 kg. The cable is attached to the top of the top circle. The hinge is attached to the rightmost side of the bottom circle. The cable makes an angle of 55°with the wall.
(a) Find the centre of mass of the sign.
(b) Find the tension in the supporting cable.
(c) Find the horizontal and vertical components of the hinge force.



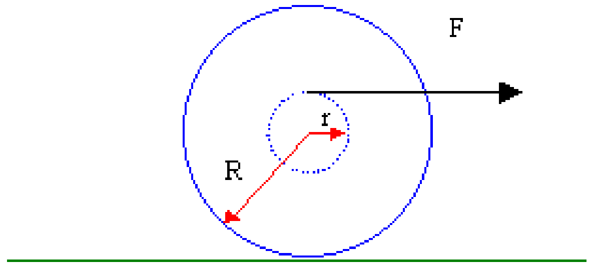
5. A solid cylinder of mass M is pulled from rest by a constant force F applied to an axle going through its centre of mass. The cylinder slides along for a distance L until point A where it encounters a rough surface where the coefficients of friction are μ_s and μ_k. Here the cylinder starts to slip.
   (a) Find the velocity of the cylinder at point A.
   (b) Find an expression for the time it takes the cylinder start rolling without slipping.
   (c) BONUS: Find the minimum value of F for which the cylinder never starts rolling without slipping.



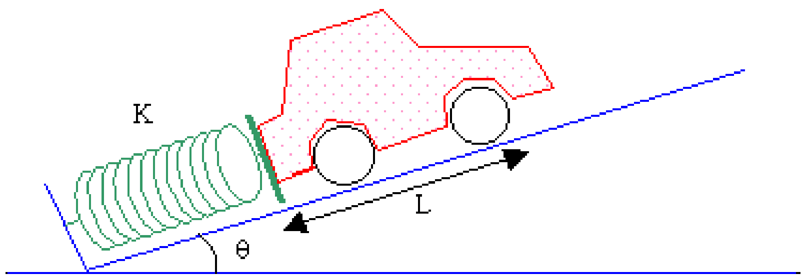
6. The diagram below shows two bicyclists on a long straight hill. Initially bicyclist B is 20.0 m ahead of Bicyclist A. Bicyclist A has an initial velocity of 54.0 km/h but stops pedalling and slows at 0.75 m/s^2. Bicyclist B maintains a constant velocity of 28.8 km/h.
   (a) What is the earliest time that the bicyclists will pass one another?
   (b) How far from Bicyclist A's initial position will this occur?
   (c) What is the latest time that the bicyclists will pass one another?
   (d) How far from Bicyclist A's initial position will this occur?



7. A yo-yo with mass M, moment of inertia I, inner radius r, and outer radius R is initially at rest. It is then gently pulled by a force F as shown in the diagram below. The coefficients of friction between the yo-yo and the table are μ_s and μ_k. The yo-yo rolls without slipping. Find the acceleration of the yo-yo.



8. The diagram below shows a toy car being pressed a distance L into an ideal spring of spring constant K. The toy car and spring are on an incline that makes an angle θ with horizontal. When released the four car wheels roll without slipping. Find the speed of the car when it has travelled distance L from its current position back to the spring's equilibrium position. The toy car has four wheels that are solid cylindrical disks, each having mass m_w. The body of the toy car has mass M.



9. A flat disk of mass 15.0 kg and radius 0.45 m is rotating clockwise about a fixed axle at 20 rad/s as shown on the left below. On the same axle, but above the disk and rotating independently, is the object shown in the middle diagram below. It consists of two flat square plates joined at a corner. The mass of the total object is 10.0 kg. The length of the side of one square is 0.30 m. The object is rotating counterclockwise at 13 rad/s. The object is allowed to drop onto the disk. After some slipping and sliding, the two start rotating at the same rate as shown in the diagram at the right.
(a) Find the direction and rate at which the objects finally rotate.
(b) How much energy is lost to the slipping and sliding?