1.(10%) A flexible chain of length L slides off the edge of a frictionless table (see Fig. 1). If, initially, a length y_0 hangs over the edge.
(a) Find the acceleration of the chain as a function of y.
(b) Find the velocity of the chain as it leaves the table completely and becomes vertical.

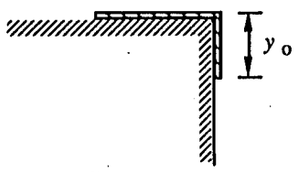

Fig. 1

2.(16%) A young man is driving a car of wheel span D at speed v around an unbanked curve of radius r. If the mass of the car is m and the center of mass of the car is H above the ground. Find the critical speed at which the car tends to overturn. Neglect the driver's mass.

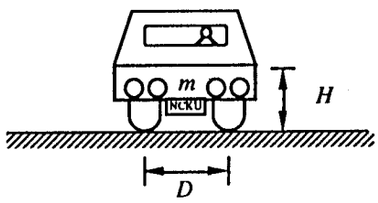

Fig. 2

3.(12%) In Fig. 3, the system is filled to height h with an incompressible liquid of density ρ. The atmospheric pressure is P_{atm}. Neglect fluid friction and assume the flow is steady.
(a) Find the flow speed of the fluid at each point. Assuming the cross section at point 3 is half that of point 5.
(b) Evaluate the pressure of the fluid at points labeled as 1 to 5.

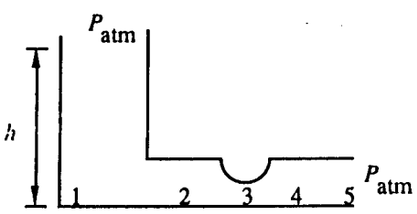

Fig. 3

5.(14%) A boy is walking away from a wall at speed of 1.0 m/s in a direction at right angle to the wall. As he walks, he blows a whistle steadily. A stationary observer facing the boy hears 4.0 beats per second. If the speed of sound is 340 m/s, what is the frequency of the whistle?

5.(14%) A system consisting of n moles of an ideal gas undergoes a reversible, isobaric process from a volume V_0 to a volume $3V_0$. Calculate the change in entropy of the gas.

6.(24%) A nonconducting sphere of radius a , which carries a uniformly distributed charge $+Q$, is at the center of an uncharged thick metal shell of inner radius b and outer radius c, as in Fig. 4.

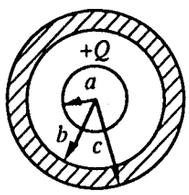

Fig. 4

(a) Determine the electric field at all the regions of space (i.e., $r < a$, $a < r < b$, $b < r < c$, and $r > c$).
(b) Find the electric potential at the region $r < a$ with respect to the infinity.
(c) Calculate the total electric potential energy of the system.
(d) What are the surface charge density at the surfaces $r = b$ and $r = c$?

7.(10%) A spherical shell of radius a carries a uniform surface charge. If the surface charge density on the shell is σ and the shell is spinning on an axis through its center with an angular velocity ω.. Find the magnetic moment of the sphere.