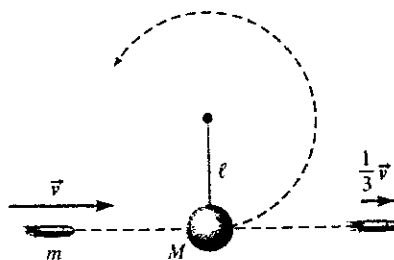


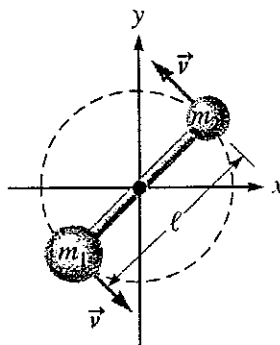
※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (10%) A pendulum consists of a wooden bob of mass M suspended by a massless rod of length l . A bullet of mass $m \ll M$ is fired horizontally with speed v at the bob and emerges from the bob with speed $v/3$ as shown in Figure. If the pendulum bob just barely reaches the highest point such that it is able to swing through one complete circle, find an expression for the speed v of the bullet before the collision.



2. (10%) A source emits sound with a frequency of 450 Hz and is moving with a speed of 25 m/s . An observer driving a car at a speed of 30 m/s is chasing the source. Assume the speed of sound is 340 m/s . What is the observed frequency by the observer?

3. (10%) Two particles of mass $m_1 = 3.00 \text{ kg}$ and $m_2 = 8.00 \text{ kg}$ are joined by a uniform massless rod of length $l = 3.00 \text{ m}$ (Figure). The system rotates in the xy plane about an axis through the mid point of the rod in such a way that the particles are moving with a speed of 4.00 m/s . What is the angular momentum of the system?

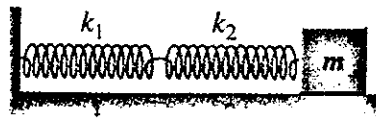


4. (10%) A solid sphere of radius R has a density that varies as $\rho = \rho_0(1 - r/2R - r^2/3R^2)$ where r is the distance from the center. Determine the variation of the field strength with r within the sphere ($r < R$).

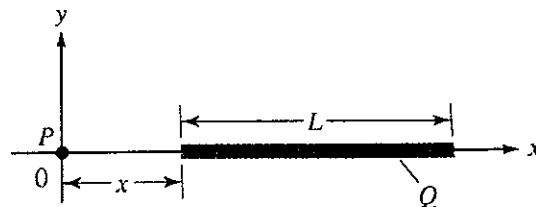
5. (15%) According to the van der Waals equation of state for one mole of a real gas, the pressure P and volume V at a temperature T are related by $(P + \frac{a}{V^2})(V - b) = RT$, where a and b are constants. Obtain an expression for the work done by the gas at a fixed value of T when the volume changes from V_i to V_f .

6. (15%) Two springs, with spring constants k_1 and k_2 , are connected to a block of mass m on a frictionless, horizontal table (Figure). The block is extended a distance x from equilibrium and released from rest. Show that the block executes simple harmonic motion with a period given by

$$T = 2\pi\sqrt{\frac{m(k_1 + k_2)}{k_1 k_2}}$$



7. (15%) Consider a thin rod of total charge Q and length L (Figure). Find that the electric potential at point P , a distance x from the end of the rod.



8. (15%) At the instant shown in both sketches in the figure, a positively charged particle ($q = 10 \text{ mC}$) travels with speed $v = 350 \text{ m/s}$ in a magnetic field with $B = 0.7 \text{ T}$. The angle θ is 40° . Find the magnetic force (magnitude and direction) exerted on the particle in both cases.

