1. A particle of mass \( m \) is traveling at constant velocity \( \vec{v}_0 \) in x-direction toward a rest uniform disk of mass \( M \) and radius \( R \) on \((x,y)\) plane that is free to rotate about a pivot through \( z \)-axis at the center of the disk (as the origin). Before strikes the disk, the particle is traveling along a line \( y = b(R > b > 0) \) in \((x,y)\) plane. The particle strikes the disk and sticks to a point on the disk with distance \( R \) from the center.
(a) Before collision what is the total angular momentum vector of the system? (5%)
(b) What is the angular velocity of the system just after the collision? (5%)
(c) What is the kinetic energy of the system after collision? (5%)
(d) How much mechanical energy is lost in this collision? (5%)

2. A balloon is used to lift a load of 10kg. The mass of the balloon’s skin is 5kg. The volume of the balloon when fully inflated is 30m\(^3\). At altitude \( h = 0 \), the temperature of the air is 0\(^\circ\)C and the atmospheric pressure is \((1\ atm.)\), the air mass density is 1.3kg/m\(^3\) and the gas density is 0.18kg/m\(^3\). The balloon is inflated with sufficient gas that the net force on the balloon and its load is 30N (Newton). Neglect changes of temperature with altitude \( h \). The universal gas constant is \( R = 8.31 \times 10^{-5} \text{m}^3 \text{atm} / (\text{mol} \cdot \text{K}) \). Following the law of atmospheric, the fractional decrease in atmospheric pressure is proportional to the change in altitude \( (\Delta P / P = -\Delta h / 8km) \), temperature is constant in altitude, and the ideal gas law is applicable.
(a) How many moles of gas are contained in the balloon? (5%)
(b) At what altitude will the balloon be fully inflated? (5%)
(c) Determine the buoyant force on the balloon at the altitude that the balloon is fully inflated. (5%)
(d) Does the balloon reach the altitude at which it is fully inflated? (5%)

3. A transverse wave satisfies the wave equation \( \frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 y}{\partial t^2} \) propagates down a string.
Where \( y \) is the vertical displacement at the point \( x \) on the string and \( v \) is the wave speed.
If the wave frequency is 20Hz, and two points 1cm apart are out of phase by \( \pi / 3 \).
(a) What is the wavelength of the wave? (5%)
(b) At a given point, what is the phase difference between two displacements for times 0.005sec. apart? (5%)
(c) What is the wave velocity? (5%)

4. A box is divided into two identical partitions.
(a) If on one side is 1mole of ideal gas A, on the other side is empty. Calculate the change in entropy when the partition is lifted. (5%)
(b) If on one side is 1mole of ideal gas A, on the other side is 1mole ideal gas B which is different from gas A but at the same temperature. Calculate the change in entropy when the partition is lifted and the two gases mix together completely. (5%)
(c) If we repeat the process as in (b) with the same type of gas in each side. Calculate the change in entropy when the partition is lifted. (5%)

注意：背面有試題
5. An infinitely long cylindrical shell is coaxial with the z-axis and has a radius of $R$ carries a uniform surface charge density $\sigma$. A spherical shell of radius $R$ is centered on the x-axis at $x = 3R$ and carries a uniform surface charge density ($-2\sigma$).
   (a) Calculate the electric field at the origin (inside the cylindrical shell). (5%)
   (b) Calculate the electric field at the point $x = 1.5R, z = 0.5R$ on the x-z plane. (5%)
   (c) Calculate the electric field at the point $x = 3R, z = 0.5R$ on the x-z plane. (5%)

6. A coaxial cable consists of two thin conducting cylinders of radii $R_i$ and $R_o (> R_i)$. Current $I$ goes in one direction in the inner cylinder and in the opposite direction in the outer cylinder.
   (a) Calculate the magnetic field at the distance $r (r < R_i)$ from the axis of the cable. (5%)
   (b) Calculate the magnetic field at $r (R_i < r < R_o)$ in the region between the two thin conductors. (5%)
   (c) Calculate the magnetic field at the distance $r (r > R_o)$ from the axis of the cable. (5%)