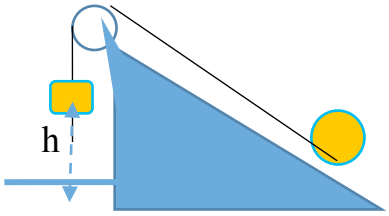
UNIVERSITÀ degli STUDI di CATANIA

Dottorato di Ricerca in Fisica- XXXVI Ciclo – Prova scritta

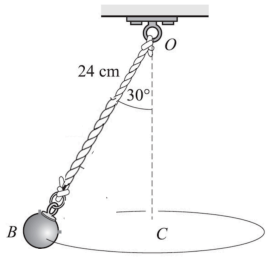
1) A solid cylinder with mass **M = 12 kg** and radius **R** lies on an inclined plane **(θ = 30 °)**. An inextensible wire of negligible mass is connected to the axis of the cylinder and to a suspended mass **m = 8 kg** as shown in the figure. The mass of the pulley can be neglected. Initially the mass **m** is at a height **h = 2 m** from the ground and when it is left free the cylinder rises with pure rolling motion. The momentum of inertia of the cylinder with respect to the axis passing through the center is **I = ½ M R²**. Determine:
a) The speed with which the mass **m** touches the ground;
b) The maximum height reached by the cylinder center with respect to the initial position.



2) A horizontal copper rod (suppose resistivity, ρ=0,016 Ω mm²/m), of length l = 50 cm, with ends A and B, is pivoted in A to a vertical pin and rotates around this with constant angular velocity of frequency ν= 1,5 s^{-1} in a region where the vertical component of the earth's magnetic field is H .
a) If the f.e.m. induced between the ends of the rod (assuming $\mu_r = 1$ for air, and $\mu_0 = 4\ \pi\ x10^{-7}$ H/m - international metric system-SI-) is $\Delta V = 3{,}11x10^{-5}$V , calculate the magnetic field H .
b) Suppose to create the closed circuit with a suitable conductor C which connects the ends A and B, and of resistance R=0,01Ω and that the rod AB has a cross section S = 1 mm².
Evaluate the current i in the circuit.

3) Determine the magnetic dipole moment of the electron revolving around the proton, according to the Bohr model of the hydrogen atom. Assume that the atom is in its ground state and the electron's circular orbit radius is $0{,}53x10^{-10}$ m. [k = $8{,}99x10^{9}$ Nxm^2xC^{-2}]

4) As depicted in the figure, a ball B is fastened to one end of a 24-cm string of negligible mass.The other end of this inextensible string is fixed at point O. Friction is negligible. The ball whirsl in the orizontal circle shown in the figure. Find the speed of the ball in its circular path, if the string makes an angle of 30° to the vertical.



5) A particle of mass $m = 8m_e$, where m_e is the electron mass, is contained in a one-dimensional box of infinite walls placed at $x = 0$ and $x = a = 1nm$. The potential energy is zero in $0 < x < a$.

- Derive the eigenenergies and normalized eigenstates.
- Calculate the wavelength of the spectral line corresponding to the decay of the first excited state. In which region of the electromagnetic spectrum does it fall?