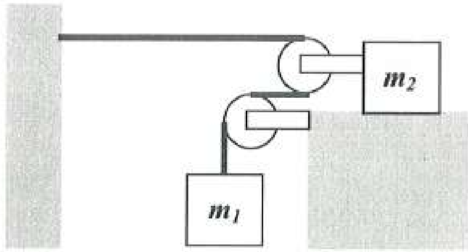
METÓDY RIEŠENIA FYZIKÁLNYCH ÚLOH zima20 – Príklady 6

Cvičenie 10.12.2020

Príklad 1

4. Two masses, two pulleys and a rope

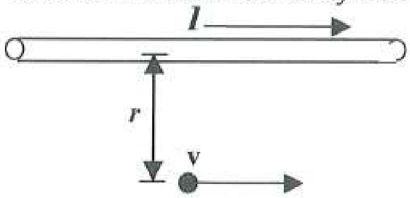
A block of mass m_1 is attached to a massless ideal rope. The rope goes around a massless pulley and then goes around a second massless pulley that is attached to a block of mass m_2 which is free to slide on a frictionless table. The other end of the rope is anchored to a wall. What is the acceleration of m_1 when the system is released?



Príklad 2

3. Current carrying wire

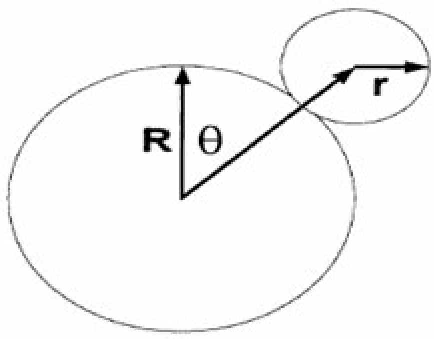
An electron of mass m moves at velocity v parallel to a wire carrying current I. The electron is a distance r away from the wire. This is the frame F.



a. Find the force on the electron due to the current in the wire.
b. Find a frame F' in which there is no magnetic force on the electron. Find all forces on the electron in F'.

Príklad 3

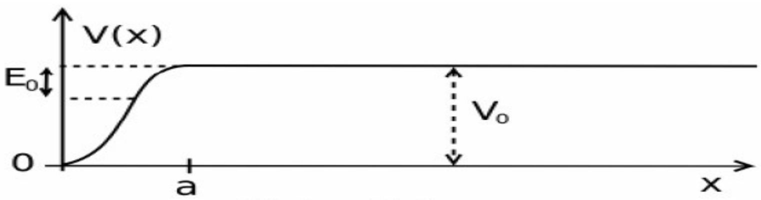
A uniform sphere of radius r and mass m rolls without sliding on the outer surface of a stationary sphere of radius R. The position of the rolling sphere is described by angle, θ, as shown in the figure. If the upper sphere starts from rest at the top of the stationary sphere ($\theta = 0$),



a) Find the velocity of the center of mass of the moving sphere as a function of θ.
b) Determine that value of θ at which the moving sphere flies off the stationary one.
c) If the moving sphere begins at $t = 0$ with $\theta = 0$ but $\dot{\theta}(0) \neq 0$ find $\theta(t)$ in terms of $\dot{\theta}(0)$ for small t.

Príklad 4

A one-dimensional attractive potential well, $V(x)$, binds a mass m particle to a reflecting wall. The binding energy is $-|E_0|$ relative to $V(x)$ at large distances away.



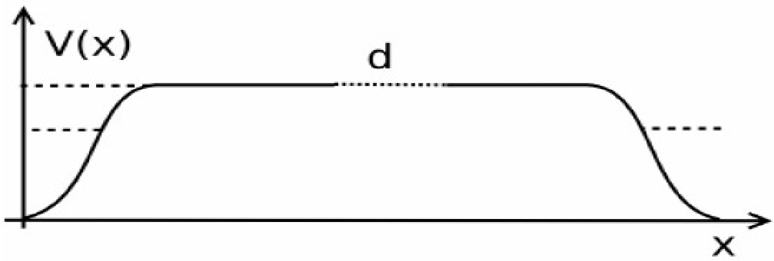
$$V(x) = V_0 \text{ for } x > a, \quad (2)$$
$$= 0 \text{ for } x = 0 \quad (3)$$

For $x \gtrsim a$ the particle wavefunction is $\psi_0 = ke^{-\alpha x}$.

(a) What is α?

(b) Estimate k if the probability for the particle being inside and outside the potential well are comparable.

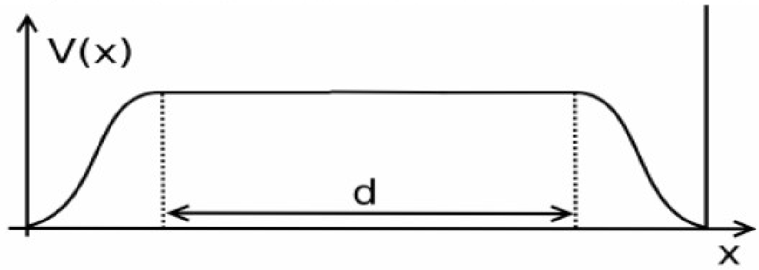
Now suppose that after a long interval d ($d \gg a$), $V(x)$ drops back to its value at $x = 0$.



If at time $t = 0$ the particle is in the state with wavefunction ψ_0 the probability for still finding it near the wall at later times is a diminishing function of time $P(t) \sim e^{-t/\tau}$.

(c) Estimate τ.

A reflecting wall is now also inserted at a distance $x = a + d + a$ from the first one at $x = 0$ so that the potential and reflector at either end mirror each other.



(d) What is the new ground state from combining $\psi_0(x)$ and $\psi_0(d - x)$?

(e) Estimate its tiny energy shift, δE, relative to $-|E_0|$. (Assume that $\psi_0 = ke^{-\alpha x}$ is an adequate approximation for all x.)

(f) What is the new $P(t)$? How does the time for it to drop to, say, $\frac{1}{2}$ compare to that for c)?