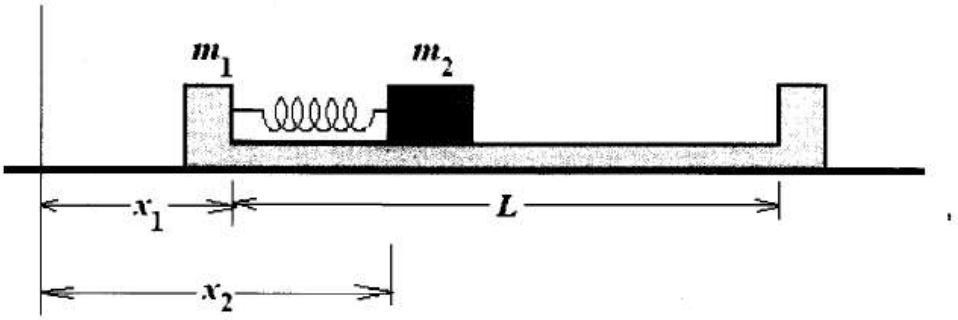
METÓDY RIEŠENIA FYZIKÁLNYCH ÚLOH 3 leto22 – Príklady 2

Cvičenie 3.3.2022

Príklad 1

A block of mass m_2 slides inside a cavity of length L inside a second block of mass m_1 which rests on a horizontal table. The masses m_1 and m_2 are connected by a massless spring with spring constant k and equilibrium length $l \ll L$. Initially both blocks are at rest and located at $x_1 = 0$ and $x_2 = l - \Delta l$ where Δl specifies the initial compression of the spring.



(a) If the mass m_1 slides without friction on the table and m_2 slides without friction on the second block, find $x_1(t)$ and $x_2(t)$ as a function of time.

(b) If the mass m_1 exerts a frictional force on m_2 proportional to their relative velocity, $F_{1 \text{ on } 2} = -\sigma(\dot{x}_2 - \dot{x}_1)$, again determine the resulting motion of the two masses.

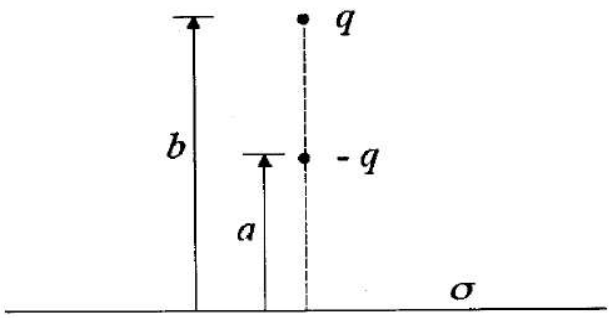
(c) If m_2 slides on m_1 without friction but m_1 experiences a similar frictional force from the table, $F_1 = -\sigma\dot{x}_1$, find the resulting complex frequencies to first order in σ assuming σ to be small. What do those frequencies imply about the resulting motion?

Príklad 2

A positive point charge q is fixed 1 cm above a horizontal, grounded conducting x-y plane. An equal negative charge $-q$ can be moved along the perpendicular dropped from q to the plane.

(a) Where should $-q$ be placed for the total force on it to be zero?

(b) Taking the distance between q and the plane equal to b, and the distance from $-q$ to the plane equal to be a, what is the surface charge density, $\sigma(x, y)$, on the conductor? Express your answer in terms of a, b, q, x and y.



Príklad 3

Neutron Star: Consider a neutron star, a macroscopic body composed of neutrons, at a density of 10^{14} g/cm^3. The temperature of the star's interior is approximately 10^7 K. For this problem you should consider the star to be a noninteracting Fermi gas of neutrons.

(a) Determine whether the neutrons are relativistic or nonrelativistic, by estimating their kinetic energy.

(b) Determine whether or not the neutrons are reasonably well considered to be a zero-temperature Fermi gas.

(c) Estimate the pressure in the neutron star.

(d) Use (c) to estimate the *mass* of this neutron star.

Príklad 4

A particle of mass m is contained within an impenetrable one-dimensional well extending from $x = -\frac{L}{2}$ to $x = +\frac{L}{2}$. The particle is in its ground state.

(a) Find the eigenfunctions of the ground state and the first excited state.

(b) The walls of the well are instantaneously moved outward to form a new well extending from $-L < x < +L$. Calculate the probability that the particle will stay in the ground state (of the new well configuration) during this sudden expansion.

(c) Calculate the probability that the particle jumps from the initial ground state to the first excited final state.

(d) Find the probability od jumping from a general initial state *n* to a general final state *m*.