UNIVERSITÄT LEIPZIG

FAKULTÄT FÜR PHYSIK UND GEOWISSENSCHAFTEN

EXPERIMENTAL PHYSICS 1

EXERCISE 2
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Problem 1: Derivatives **6 · 2 Points**

a. Calculate the first derivative with respect to x of the functions:

$$f(x) = \arcsin\left(\left(\mathrm{a}^3 x^3 \mathrm{e}^{-\mathrm{bx}}\right)^{-\frac{1}{2}}\right)$$

$$f(x) = \tan\left(\sqrt{1 + a^{x^2}}\right)$$

b. Calculate the first partial derivative with respect to y:

$$g(x,y) = y^3 + 3y^2 z + 3yz^2 + z^3$$

$$g(x,y) = e^{y^2 \arctan(yz)}$$

c. Calculate the integral of

$$f(x) = \frac{1}{x \ln(ax)}$$

$$f(x) = \frac{1}{a^2 + bx^2}$$

d. Calculate the integral between the limits:

$$f(x) = \cos^3(x)\ ,\ \text{limits: } \pi/6 \ldots \pi/4$$

$$f(x) = xe^{-x^2},\ \text{limits: } -1 \ldots +1$$

e. Use the technique of implicit differentiation to calculate the derivative of $\operatorname{arctanh}(x)$.

f. Give a non-trivial example for a function with horizontal asymptotes for $x \to \pm\infty$ and zeroes at ± 5.

Problem 2: Forces, Skateboards **2 + 2 Points**

Prof. S ($m_1 = 70\ \mathrm{kg}$) and Mr. M ($m_2 = 105\ \mathrm{kg}$) are standing on Skateboards. Each of them holds the end of a rope which has a length of $L = 20\ \mathrm{m}$. At $t = 0$ they both start to pull on it with a force of $10\ \mathrm{N}$.

a. Assuming they uphold a constant force, where do they meet? (Prof. S starts at Position 0, Mr. M at $x = L$)

b. What is their speed when they meet?

The mass of the skateboard and its friction are ignored. The mass of the rope is ignored as well.

Problem 3: Mass falling on a Coil (Newton) **$3 + 2$ Points**

A mass of $300\ \mathrm{g}$ falls under the action of gravity onto a vertical coil spring (spring constant $D = 2.5\ \mathrm{N/cm}$). The spring is compressed by $20\ \mathrm{cm}$ until the mass reaches its lowest position.

a. What is the velocity of the mass just before touching the spring?
b. If the mass is doubled, what is the distance by which the spring would be compressed?

Neglect friction. Solve by integration of Newton's force equation, not using conservation of energy!

Problem 4: Stone out of a Window **$2 + 2 + 2$ Points**

A stone is thrown horizontally out of the window from a car at right angle to the car's velocity. It hits the ground at a point that is $z_0 = 1\ \mathrm{m}$ below, $y_0 = 10\ \mathrm{m}$ away (in perpendicular direction (y) to the road) and $x_0 = 30\ \mathrm{m}$ away (in the direction (x) along the velocity of the car) from the point of throw.

c. Calculate the speed v_C of the car,
d. the initial speed $|\vec{v}_S|$ of the stone
e. and the velocity $\vec{v}_{fin}$ and speed $v_{fin} = |\vec{v}_{fin}|$ of the stone as it hits the ground.

Tasks to think about:

Task 1:

Fig. 1 shows schematically a bundling process of actin filaments (red) in a solution with smaller polymers (black).
Are forces required for this type of demixing?

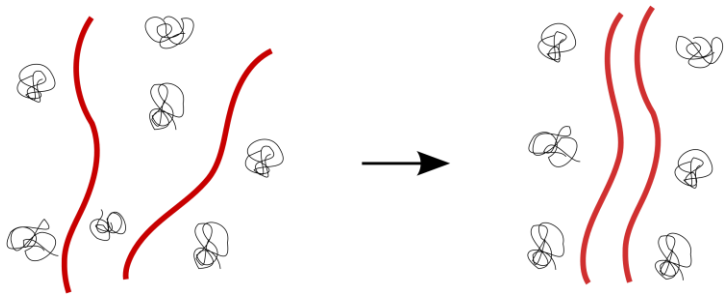

Figure 1

Task 2:

The nearest star to our solar system is Proxima Centauri with a distance of about 4.247 light years.
If one wants to travel from the earth to the moon, the escape velocity of 11.2 km/s must be reached.
What speed must be reached to achieve interstellar travel? What kind of spacecraft propulsion is needed and what other problems have to be overcome?