UNIVERSITÄT LEIPZIG

FAKULTÄT FÜR PHYSIK UND GEOWISSENSCHAFTEN

EXPERIMENTAL PHYSICS 1

EXERCISE 3

Date of Issue 2nd of November 2022

Lecturer: Prof. Josef A. Käs
Tutor: Dimitrij tschodu
E-Mail: dimitrijtschodu @googlemail.de

Problem 1: Descent **5 Points**

Another satellite is on a spherical orbit around the earth in a couple of thousand kilometres height. Due to old satellite debris floating around, it loses very slowly energy. The orbiting height slowly reduces but the trajectory will stay circular for the whole descent in good approximation. Describe the descend of the satellite, in terms of height, forces, kinetic energy and potential energy over time, until it reaches a critical height and gets in contact with the earth's atmosphere.

Problem 2: Constant Friction, Locomotive **3 Points**

What mass m_{loc} does a locomotive need to have so it can pull a number of wagons with a total mass of $m_{\mathrm{wag}} = 400\,\mathrm{t}$ on a horizontal track and constantly accelerate them from $v_0 = 0\ to\ v_1 = 72\ \frac{\mathrm{km}}{\mathrm{h}}$ within a distance of $d = 1\,\mathrm{km}$. The friction coefficient between the wheel of the locomotive and the track is $\mu = 0.12$.

Problem 3: Plane and Volume Integrals **5 · 2 Points**

a. Evaluate $\iint_D x^2\,\mathrm{d}A$, where D is the ring-shaped region given by $4 \leq x^2 + y^2 \leq 9$
b. Evaluate $\int_{x=0}^{1}\int_{y=0}^{1}\int_{z=0}^{1} x\,y\,z\,\mathrm{d}z\mathrm{d}y\mathrm{d}x$
c. Evaluate $\int_{x=0}^{1}\int_{y=0}^{1}\int_{z=\sqrt{x^2+y^2}}^{2} x\,y\,z\,\mathrm{d}z\mathrm{d}y\mathrm{d}x$
d. Find $\iint_R (x + y^2)\mathrm{d}x\mathrm{d}y$ over the region R bounded $y = x$ and $y = x^2, 0 \leq x \leq 1$
e. Find $\iiint_T [(x + y)^2 - z]\mathrm{d}x\mathrm{d}y\mathrm{d}z$, where the region T is bounded by the surface $z = 0$ from below and $(z - 1)^2 = x^2 + y^2$ from above.

Problem 4: Spring under gravity $\mathbf{2 + 1 + 1 + 1}$ **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. Draw sketches for the experimental setup in the situations described in b) and d) side by side and include an appropriate coordinate system.
b. What is the velocity of the mass just before touching the spring?
c. If the mass is doubled, what is the distance by which the spring would be compressed?
d. After a while, due to friction, the system comes to halt and the mass is sitting still on the spring. How much is the spring compressed?

Task to think about:

In physics, conservative forces are forces that perform no work along any closed path (closed loop). Energy expended on partial paths is recovered on other paths. This means that the energy of a specimen is conserved at the end.
Forces like the gravitational force, Coulomb force and van der Waals force have a radial dependency which extends to infinity. Most central force fields are conservative and attractive on a macroscopic level. Repulsive forces exist rather in short range.
Does this mean that the world collapses?