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Exercises and Complements for the Introduction to Physics I for Students of Biology, Pharmacy and Geoscience

Sheet 6 / October 25, 2017 Discussion of the Exercises: **31.10.2017/01.11.2017**

Exercise 22.

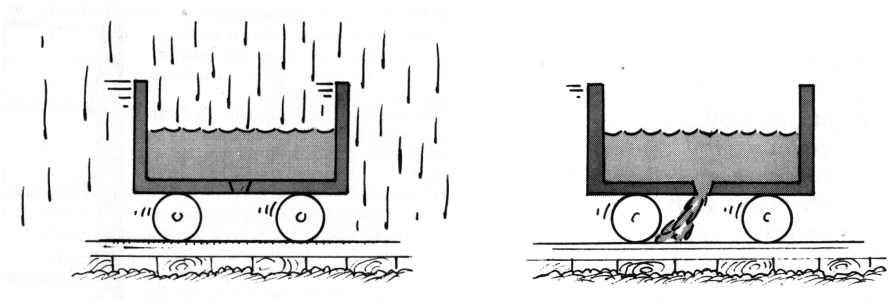
An object with the mass $m_1 = 2\,\text{kg}$ and the velocity $v_1 = 24\,\text{km/h}$ collides elastically with a resting object (m_2). Both objects are moving after the collision with the same velocity but the opposite direction away from each other.

(a) How big is the mass m_2 of the second object?

(b) How big is the absolute value of the velocity after the collision?

Exercise 23.

An open wagon rolls without friction. It rains vertically into it, whereby a non negligible amount of water is collected, see figure. Think about the effect of the collected water on the velocity, the momentum and the kinetic energy of the wagon.



It stopped raining. The drain plug at the bottom of the wagon gets pulled out, so that the water can flow out of the wagon, see figure. What happens with the velocity, the momentum and the kinetic energy?

Exercise 24.

Two vehicles with the same mass m have a perfectly inelastic frontal collision with each other, whereby

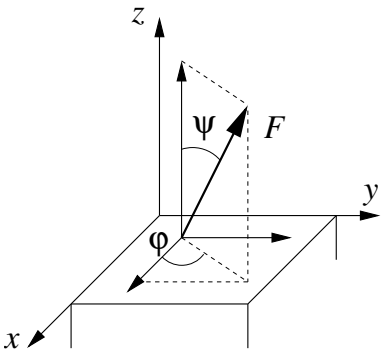
(a) both vehicles drive with the equal velocity v towards each other
(b) one vehicle has the velocity $2v$ and crashes into the other vehicle which is resting.

Calculate for both cases: How big is the work by destruction respectively the amount of the original kinetic energy which gets transformed into heat?

Exercise 25.

A person ($m = 75kg$) sits on a rotatable chair and has his arms outstretched. In each hand he holds a dumbbell with a mass of 2 kg each. The dumbbells have a distance to the axis of rotation of 75 cm. The rotation of the person and the chair is initiated through a one time push, so that in each second he makes half a rotation. How is the angular velocity changing if the person changes the position of the weights, the person is reducing the distance of the weights to the rotation axis by 65 cm? The moment of inertia of the person and the chair are: $J_P = 1.95$ kg m^2, $J_C = 0.27$ kg m^2 (the change of the position of the arms as well as the friction are neglected).

Additional exercise 26.



We have a cube made out of Aluminum (Young's modulus or also known as elastic modulus $E = 73$ GPa, shear modulus $G = 27$ GPa) with a length of the edges of the cube of $l_0 = 1$ cm. The cube is fixed at the base. At the topmost surface $A = 1$ cm^2 a force with an angle of $\varphi = 30°$ in x-direction and $\psi = 45°$ in z-direction (normal to the surface) is applied, see figure. The tension force of $F = 10$ kN is distributed homogeneously over the topmost surface.
(a) Calculate the normal stress in z-direction and the shear stress in x- and y-direction.
(b) Calculate the expansions and shears corresponding to the stress calculated in (a).

Solutions.

Exercise 22. (a) $m_2 = 6$ kg, (b) $|v'| = 3.35$ m/s

Exercise 25. $\omega_2 \approx 2\omega_1$

Additional exercise 26. (a) $\sigma_{zz} = 70.7$ MPa, $\tau_{zx} = 61.2$ MPa, $\tau_{zy} = 35.4$ MPa, (b) $\Delta l = 0.01$ mm, $\Delta s_x = 0.023$ mm, $\Delta s_y = 0.013$ mm