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

Sheet 6 / 22.10.2020 Zoom - Q&A on the Exercises: **27.10.2020/28.10.2020**

Exercise 26.

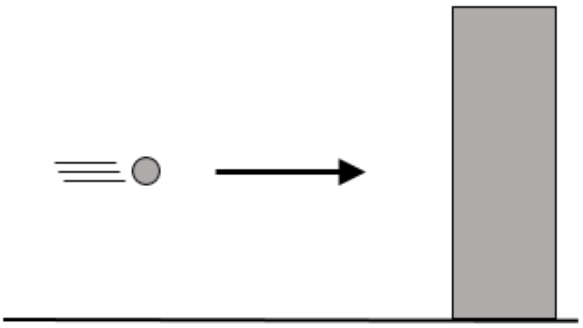
An object with the mass $m_1 = 2\,\text{kg}$ and the velocity $v_1 = 24\,\text{km/h}$ collides elastically with a resting object (m_2). Both objects are moving after the collision with the same velocity but the opposite direction away from each other.

(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 27.

A rubber ball and an aluminum ball are both the same size, speed and mass. They are fired at a block of wood.



Which one is more likely to knock the block over?

(a) the rubber ball
(b) the Aluminium ball
(c) both similarly

Which is more likely to damage the block?

(a) the rubber ball
(b) the Aluminium ball
(c) both similarly

Hint: Consider the differences between elastic and inelastic collisions.

Exercise 28.

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 29.

A person ($m = 75$ kg) 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).

Exercise 30.

A CD with a mass $m_{\text{CD}} = 15$ g and a diameter $d_{\text{CD}} = 12$ cm (this can be seen as a flat cylinder with moment of inertia $J_{\text{cyl}} = \frac{1}{2}mr^2$) rotates with a frequency of 100 Hz inside a CD player. The CD player can be considered as a flat square cuboid (moment of inertia $J_{\text{cub}} = \frac{1}{12}m(a^2 + b^2)$) with a mass $m_{\text{player}} = 500$ g and dimensions $a = 15$ cm, $b = 15$ cm, and $c = 4$ cm
(a) Calculate the centripetal force acting on a point-like dust particle with mass 0.01 g at the edge of the CD.
(b) Calculate the rotational energy of the CD.
(c) Calculate the angular momentum of the CD.
(d) Using the conservation of angular momentum, calculate the frequency at which the CD player rotates, if the CD is played while floating in the weightless environment of space.

Solutions.

Exercise 26. (a) $m_2 = 6$ kg, (b) $|v'| = 3.35$ m/s

Exercise 29. $\omega_2 \approx 2\omega_1$

Exercise 30. (a) $F_Z = 0.24$ N, (b) $E_{rot} = 5.33$ J, (c) $L_{CD} = 0.02$ kg·m^2/s, (d) $f_{Player} = 1.44$ Hz