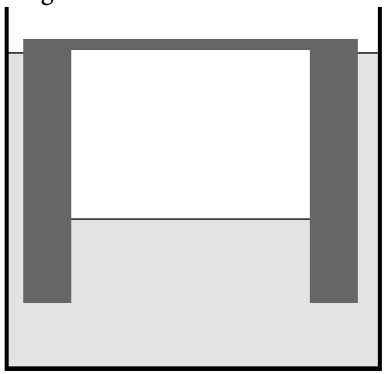
GAG—2009. Gymn.—1st year

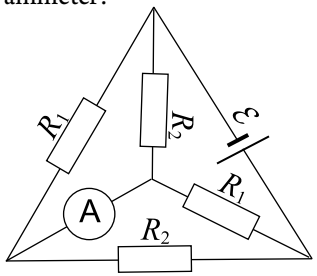
1. Pole ***(10 points)*** A pole of square cross-section is fixed vertically and is surrounded by flat ice surface. The perimeter of the pole is $p = 40\,\text{cm}$. A rope of length $l = 2\,\text{m}$ is fixed to the corner of the pole, at the ice surface. A small puck is fixed to the other end of the rope. Initially, the rope is horizontal and stretched so that the line of the rope passes through the centre of the pole; the puck rests on the ice. The puck is given a horizontal, perpendicular to the rope velocity $v = 1\,\text{m/s}$. How long time does it take for the rope to get completely winded around the pole? The rope is much lighter than the puck, neglect the friction forces.

2. Glass ***(10 points)*** A cylindrical glass with thick walls and thin bottom is turned around and put into the water, as shown in Figure (where a vertical axial cross-section is given). The figure is given with 10 times reduced scales. Using the figure (and making there the needed measurements), determine the air pressure inside the glass; the outside air pressure is $p_0 = 100.0\,\text{kPa}$. Also, determine the mass of the glass.

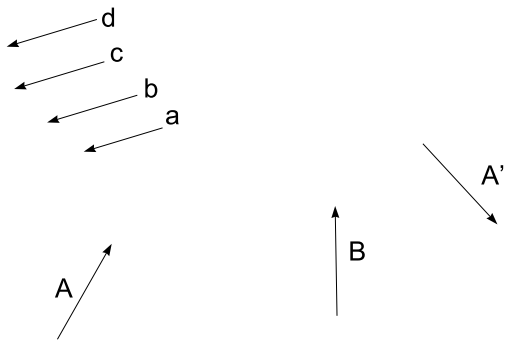


3. Ball ***(10 points)*** A tennis player hits with his racket a ball approaching with velocity $v_0 = 90\,\text{km/h}$. The velocity of the racket before the collision is $u_0 = 60\,\text{km/h}$, and after the collision $u_1 = 40\,\text{km/h}$. What is the velocity of the ball after the collision? All the velocities may be assumed horizontal, and the collision to be absolutely elastic.

4. Tetrahedron ***(10 points)*** In the electrical circuit given in the Figure, $R_1 = 1\,\Omega$, $R_2 = 2\,\Omega$, and $\mathcal{E} = 2\,\text{V}$. What is the reading of the ammeter?



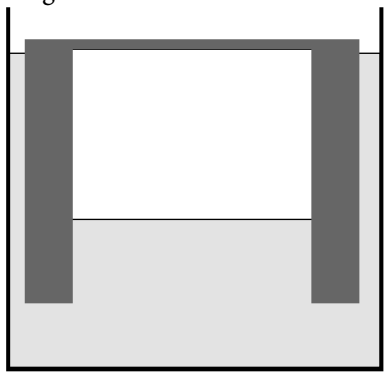
5. Concave mirror ***(10 points)*** In the Figure, a light beam is shown before and after the reflection on a spherical concave mirror (marked with A and A', respectively). Which of the four beams (a, b, c or d) is the reflected beam B? Construct the concave mirror.



GAG—2009. Gymn.—2nd year

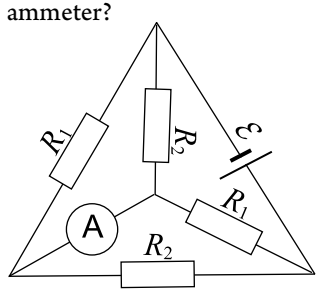
1. Pole ***(10 points)*** A pole of square cross-section is fixed vertically to a flat horizontal surface. The perimeter of the pole is $p = 40\,\text{cm}$. A rope of length $l = 2\,\text{m}$ is fixed to the corner of the pole, at the ice surface. A small puck is fixed to the other end of the rope. Initially, the rope is horizontal and stretched so that the line of the rope passes through the centre of the pole; the puck rests on the ice. Which horizontal initial velocity (perpendicular to the rope) has to be given to the puck, such that the rope would get completely winded around the pole? The rope is much lighter than the puck; the coefficient of friction between the puck and the surface is $\mu = 0.1$.

2. Glass ***(10 points)*** A cylindrical glass with thick walls and thin bottom is turned around and put into the water, as shown in Figure (where a vertical axial cross-section is given). The figure is given with 10 times reduced scales. Using the figure (and making there the needed measurements), determine the air pressure inside the glass; the outside air pressure is $p_0 = 100.0\,\text{kPa}$. Also, determine the mass of the glass.

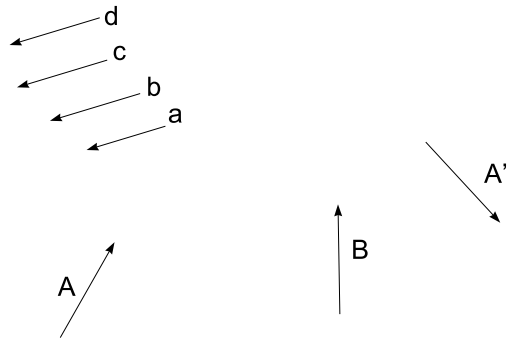


3. Ball ***(10 points)*** A tennis player hits with his racket a ball approaching with velocity $v_0 = 90\,\text{km/h}$. The velocity of the racket before the collision is $u_0 = 60\,\text{km/h}$, and after the collision $u_1 = 40\,\text{km/h}$. What is the velocity of the ball after the collision? What is the ratio of the masses of the racket and the ball. All the velocities may be assumed horizontal, and the collision to be absolutely elastic.

4. Tetrahedron ***(10 points)*** In the electrical circuit given in the Figure, $R_1 = 1\,\Omega$, $R_2 = 2\,\Omega$, and $\mathcal{E} = 2\,\text{V}$. What is the reading of the ammeter?



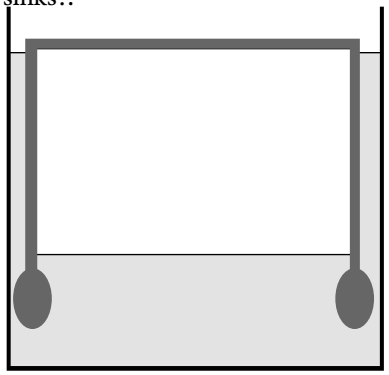
5. Concave mirror ***(10 points)*** In the Figure, a light beam is shown before and after the reflection on a spherical concave mirror (marked with A and A', respectively). Which of the four beams (a, b, c or d) is the reflected beam B? Construct the concave mirror.



GAG—2009. Gymn.—3rd year

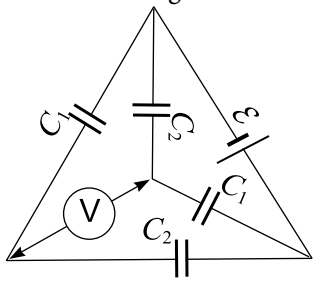
1. Magnetic field ***(10 points)*** Magnetic field with inductance B (parallel to the z-axis) fills the region $x > 0$. Electron enters this region with velocity v; the velocity vector is perpendicular to the z-axis and forms angle α with the x-axis. Sketch the trajectory of the electron. How long does the electron stay in the magnetic field?

2. Glass ***(10 points)*** A cylindrical glass is turned around and put into the water, as shown in Figure (where a vertical axial cross-section is given; the glass has a thick edge, needed for the stability of the equilibrium). The figure is given with 10 times reduced scales. Using the figure (and making there the needed measurements), determine the air pressure inside the glass; the outside air pressure is $p_0 = 100.0\,\text{kPa}$. The Figure corresponds to the outside temperature $t = 30°\text{C}$. At which temperature the glass sinks?.



3. Brick ***(10 points)*** A small brick is glued to the rapidly rotating shaft; the size of the brick is much smaller than the shaft radius $R = 10\,\text{cm}$. The glue breaks at the tension $T = 10\,\text{N}$; the mass of the brick $m = 10\,\text{g}$. At which angular velocity of the shaft ω, the brick breaks from the shaft? Sketch the trajectory of the brick on a figure, which is made at the plane, perpendicular to the shaft axis and covers an area of $50\,\text{cm} \times 50\,\text{cm}$.

4. Tetrahedron ***(10 points)*** In the electrical circuit given in the Figure, $C_1 = 100\,\mu\text{F}$, $C_2 = 200\,\mu\text{F}$, and $\mathcal{E} = 2\,\text{V}$. What is the reading of the voltmeter, when it is connected to the points shown in the Figure?



5. Convex mirror ***(10 points)*** In the Figure, a light beam is shown before and after the reflection on a spherical convex mirror (marked with A and A', respectively). Which of the four beams (a, b, c or d) is the reflected beam B? Construct the convex mirror.