Norsk Fysikklærerforening
I samarbeid med Skolelaboratoriet,
Fysisk institutt, UiO

PHYSICS OLYMPIAD 2021 - 2022

First round: October 25th - November 5th, 2021

Duration: 90 minutes
Aids: Calculator and the provided formula sheet
The problem set consists of 4 pages, and there are 10 problems in total.
The problem set consists of multiple choice problems, as well as problems where you are supposed to show how you reason. Several possible answers are given for each multiple choice problem, a capital letter is assigned to each multiple choice task. You are supposed to put a circle around the capital letter that represents the answer you think is correct. Maximum points per problem is given for each problem.
Good luck!

Problem 1 (4 Points)

A 9 V battery can provide 550 mAh, and it costs 30 kroner.

If we assume that the price per kWh from the power grid is 1.20 kroner, how much more expensive is the energy from the battery than from the power grid?

A. 25 times more expensive

B. 100 times more expensive

C. 500 times more expensive

D. 5000 times more expensive

Problem 2 (4 Points)

You are mixing 1 liter of water with the temperature 10°C and 3 liters of water with the temperature 70°C. What will the temperature of the mixture be?

A. 25°C

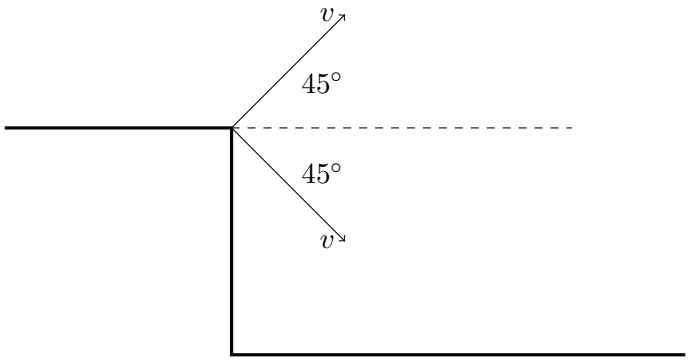
B. 35°C

C. 45°C

D. 55°C

Problem 3 (4 Points)

We are throwing two balls off an edge with the same starting point, and we disregard air resistance. We throw ball A with an angle 45° upwards. The other ball, ball B, we throw with the same speed, but now with an angle of 45° downwards.



Which ball has the greatest speed when it hits the ground?

A. A

B. B

C. They have the same speed

D. It is impossible to decide

Problem 4 (4 Points)

Between two parallel plates, each with area A and distance d between them, is a viscous liquid (a liquid that resists deformation). One of the plates is being pulled with constant speed v due to a force F. F is then proportional to A and to the speed v, and inversely proportional to the distance d. The constant of proportionality μ is called the liquid's viscosity. What are the units of μ?

A. $\frac{\mathrm{Ns}}{\mathrm{m}^2}$

B. $\frac{\mathrm{kg\ s}}{\mathrm{m}}$

C. $\frac{\mathrm{Nm}^3}{\mathrm{s}}$

D. $\frac{\mathrm{Ns}}{\mathrm{m}^3}$

Problem 5 (4 Points)

In a heavy rainfall it is coming 6.0 mm of rain per hour. We assume that the raindrops have an average diameter of 1.8 mm. Then they have a fall speed of 5.8 m/s. Approximately how much water is it per m^3 of air in such a rainy weather?

A. 0,1 g

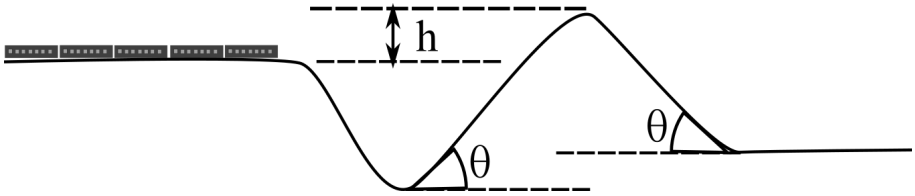
B. 0,3 g

C. 2 g

D. 4 g

Problem 6 (4 Points)

A train with length L stands still on a horizontal surface. Then we give the train a tiny amount of speed, just enough for it to begin to roll down a hill. After a while, the train comes to a mountain it must roll over. The mountain has a slope θ to the horizontal on both sides. How high above the starting point can the top of the mountain maximally be in order for the train to barely roll over it? The train has no motor, and you can disregard all friction and air resistance.



A. $h = 0$

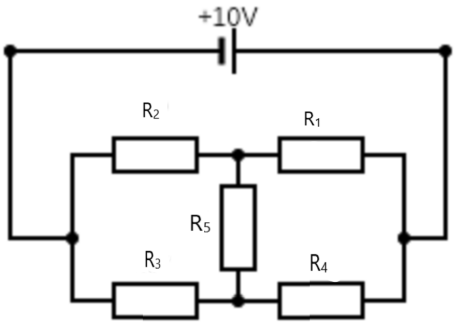
B. $\frac{1}{4} L \sin\theta$

C. $\frac{L}{4\tan\theta}$

D. $\frac{L}{4\cos\theta}$

Problem 7 (4 Points)

We have the following circuit:



$R_1 = 2\ \Omega$, $R_2 = 8\ \Omega$, $R_3 = 5\ \Omega$, $R_4 = 5\ \Omega$, $R_5 = 3000\ \Omega$. The source of voltage is 10 V and it has positive pole to the right in the figure above. Approximately how large is the current through the resistor R_5?

A. 3 mA upwards in the figure

B. 3 mA downwards in the figure

C. 1 mA upwards in the figure

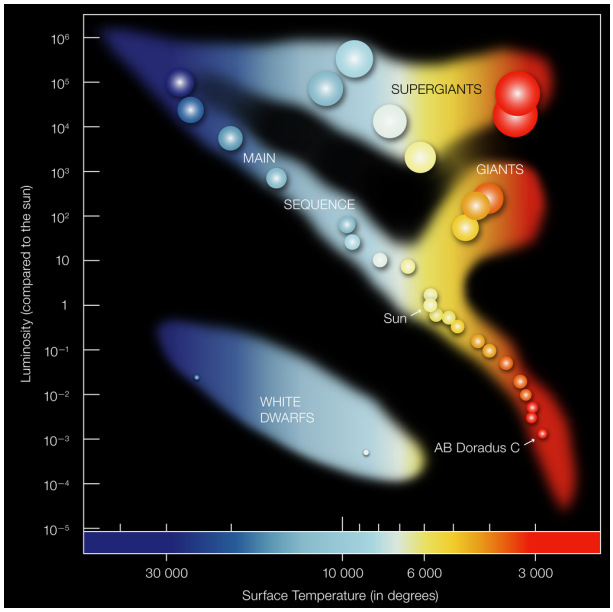
D. 1 mA downwards in the figure

E. 10 mA upwards in the figure

F. 10 mA downwards in the figure

Problem 8 (4 Points)

The figure below shows a HR-diagram (retrieved from European Southern Observatory):



Stars A and B are located in the HR-diagram, but they are not plotted in the figure. Star A has luminosity 0.01 (compared to the Sun) and temperature 10 000 K, while star B has luminosity 0.01 and temperature 3300 K. What can we then know about the masses of star A and B?

A. Star A has a masse between 1.4 and 8 solar masses, star B has a mass between 0,08 og 1 solar mass.

B. Star A has a mass between 0.08 and 1.4 solar masses, star B has a mass between 0.08 and 1 solar mass.

C. Star A has a mass between 1.4 and 8 solar masses, star B has mass above 1 solar mass.

D. Star A has a mass between 0.08 and 1.4 solar masses, star B has a mass between 1 and 8 solar masses.

E. Star A has a mass between 0.08 and 1 solar masses, star B has a mass between 1.4 and 8 solar masses.

Problem 9 (4 Points)

A small ball is being held at rest in water a distance d under the water surface. Next, we let the ball go, it rises to the surface of the water and then bounces a height h above the water surface. The ball has mass m and radius r. The water has density ρ. Disregard the buoyancy in air, air resistance, and the resistance in the water.

Find an expression for the height, h. Hint: You may need that the buoyancy can be expressed as $O = \rho V g$, where V is the volume of the ball.

Problem 10 (4 Points)

We throw two identical balls straight up in the same direction, but we do not throw them at the same time. Ball number 1 is thrown straight up at exit speed v. After a time t, ball number 2 is thrown from the same position at exit speed $2v$. Ball 2 hits ball 1 when ball 1 is at its highest point.

Find t. (Disregard air resistance and the diameter of the balls)