Mathematical Grammar School Cup

Physics Test

I Circle the correct answer

1. (1 point) What is the formula that expresses the Second Newton's Law?

A) $a = \frac{m}{F}$ B) $a = \frac{F}{m}$ C) $a = mF$ D) $a = \frac{F}{m^2}$ E) none of the above

2. (1 point) Scientist after whom the unit of power was named was:

A) Isaac Newton B) Alessandro Volta C) James Joule D) Andre Ampere E) James Watt

3. (1 point) Along the straight part of a highway a car and a bus are moving in the same direstion, at a safe distance from eachother. The bus is moving with velocity $15\,\text{m/s}$ and behind him the car is moving with velocity $72\,\text{km/h}$. How is the bus moving with respect to the car driver?

A) approaching with velocity $35\,\frac{\text{m}}{\text{s}}$

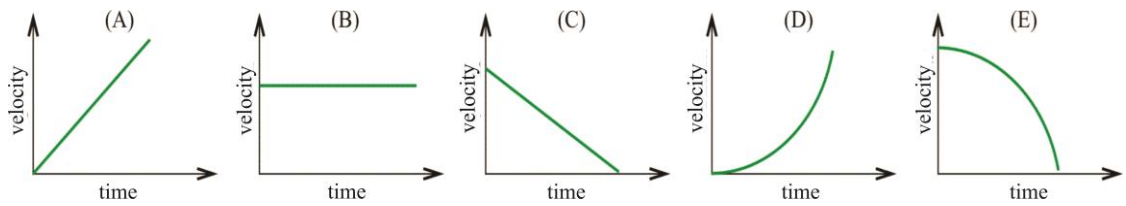
B) receding with velocity $35\,\frac{\text{m}}{\text{s}}$

C) approaching with velocity $5\,\frac{\text{m}}{\text{s}}$

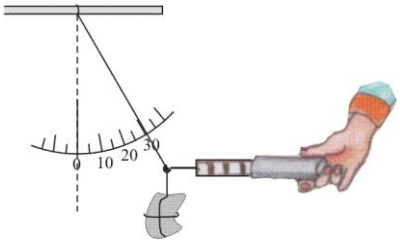
D) receding with velocity $5\,\frac{\text{m}}{\text{s}}$

E) approaching with velocity $87\,\frac{\text{m}}{\text{s}}$

4. (1 point) Boris wrote a message on a tennis ball and tossed it up in a vertical direction. Sofia, who was standing on a balcony on the second floor, caught the ball. Which of the following graphs shows how the velocity of the ball was changing during its flight? (Neglect the air resistance)



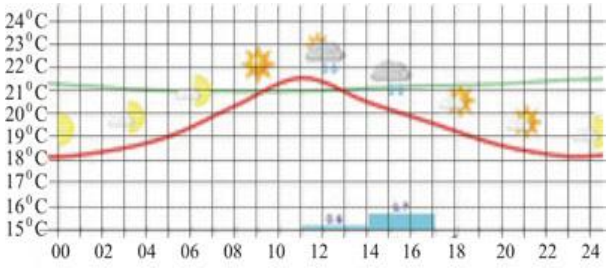
5. (2 points) Anna and Peter had a dynamometer which could measure weights up to 5 N. Still, they managed to measure an even greater weight with it (see the picture). They tied the stone using a light and unstretchable rope whose other end they



attached to a horizontal bar. Just behind the bar they put a large board with a big protractor on it. Afterwards they tied the dynamometer to the lower end of the rope and pulled it in a horizontal direction. They noticed the following: when the stone was at rest and the dynamometer was measuring the force of 5 N, the rope made a 30^0 angle with the vertical. What was the weight of the stone?

A) 5 N B) 10 N C) 7,5 N D) $5\sqrt{2}$ N E) $5\sqrt{3}$ N

6. (2 points) The picture shows a graph of temperature change during one day in a certain city.



1) What was the highest temperature (T_{max}) that day in degrees Kelvin?

2) By how much did the temperature change from 5 h (5 a.m.) to 13 h (1 p.m.) in degrees Kelvin (ΔT), and by how much in degrees Celcius (Δt)?

A) $T_{max} = 21{,}5\,\text{K}$; $\Delta T = 275\,\text{K}$; $\Delta t = 2\ ^0\text{C}$

B) $T_{max} = 294{,}5\,\text{K}$; $\Delta T = 2\,\text{K}$; $\Delta t = 2\ ^0\text{C}$

C) $T_{max} = 294{,}5\,\text{K}$; $\Delta T = 275\,\text{K}$; $\Delta t = 2\ ^0\text{C}$

D) $T_{max} = 21{,}5\,\text{K}$; $\Delta T = 2\,\text{K}$; $\Delta t = 2\ ^0\text{C}$

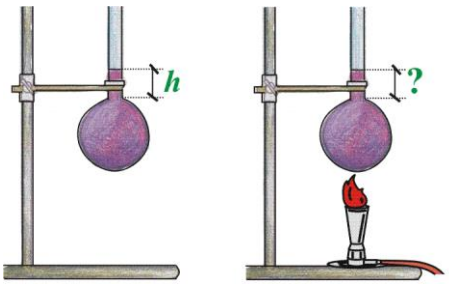
E) $T_{max} = 294{,}5\,\text{K}$; $\Delta T = 2{,}5\,\text{K}$; $\Delta t = 2{,}5\ ^0\text{C}$

II Fill in the blanks by using the following words: INCREASES, DECREASES or STAYS CONSTANT

7. (2 points) Elena is standing at the beach and sunbathing. If she goes from standing to lying down how does:

1) her weight change? _____ 2) the pressure she applies on the sand change? _____

8. (2 points) Round-bottom flask with a vertical tube in it is fixed to a stand. A colored liquid is poured in the flask so as to fill a part of the tube as well. Knowing that liquids expand more than solid when being heated, how will the height of the liquid in the tube change (h) if we put a gas burner under the flask to heat it up:



1) at first it _____,

2) and then it _____.

III Give an answer in the following form $A < B$, $A > B$ or $A = B$

9. (2 points) Specific heat capacity of a substance is defined with the formula:

$$c = \frac{Q}{m \cdot \Delta T},$$

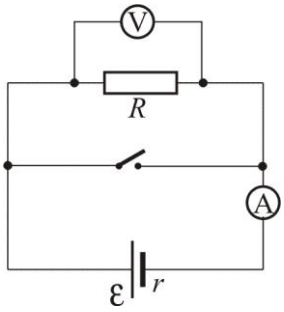
where Q is the heat that is absorbed (or released) by the substance of mass m and ΔT is the substance temperature change due to the exchanged heat.
It is known that water has a greater specific heat capacity than metals and other solid bodies.

If we put a metal pot with cold water in it on a hot stove, both the pot and the water will be heated. When the water starts boiling, the pot is removed from the stove. Considering the masses of the pot and the water contained in it to be equal and that they were in thermal equilibrium at all times compare:

1) the temperature of the pot (A) and water (B) at the moment when they were removed from the stove; _____
2) the amount of heat received during the heating process by the pot (A) and water (B). _____

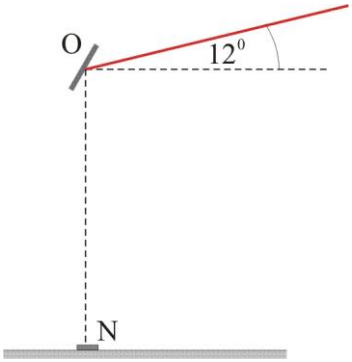
10. (2 points) In the electric circuit shown on the picture compare:

1) the currents the ammeter is showing when the switch is open (A) and when it is closed (B); _____
2) the voltages the voltmeter is showing when the switch is open (A) and when it is closed (B). _____



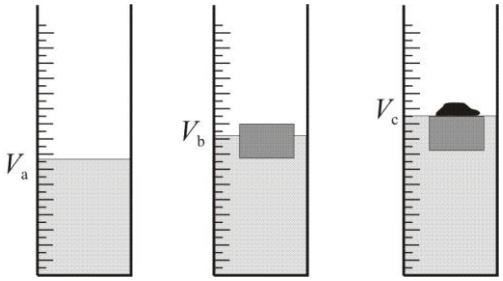
IV Solve the problems

11. (2 points) One student is pointing a laser pointer at a small plane mirror O that the other student is holding in his hand. The angle between the laser beam and the horizontal plane is 12^0. At what angle to the horizontal plane should the mirror be placed so that the laser beam hits the coin N which is on the floor, directly below the mirror (see the picture).



12. (4 points) A worker is pulling a bucket full of sand from the ground to the roof using an unstretchable rope of negligible mass (as is shown in the picture). Mass of the bucket is 20 kg and the worker is pulling it with the force of 205 N. After 4 s since the bucket started moving up (from rest), the rope broke off and the bucket fell down. Taking the gravitational acceleration to be $g = 10\,\mathrm{m/s^2}$ and neglecting the air resistance, find the maximum height reached by the bucket and its velocity just before it hits the ground.

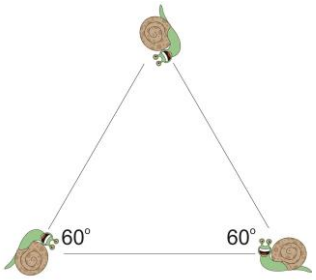
13. Students performed a following experiment in physics class (see the picture):



- In a wide graduated cylinder they poured water whose volume was $V_a = 100\,\text{cm}^3$;
- Then they placed a wooden block of unknown mass and volume in the water. In equilibrium the scale on the cylinder was showing a new volume $V_b = 120\,\text{cm}^3$;
- Next they spilled scrap metal on the wooden block slowly and carefully untill the surface of the water evened out with the surface of the wooden block. The scale on the cylinder showed the volume to be $V_c = 127\,\text{cm}^3$.

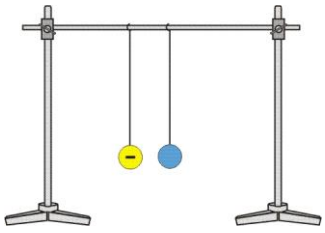
1) (2 points) Knowing that the density of water is $\rho_0 = 1\,\text{g/cm}^3$ find:
   - the mass and density of the wooden block;
   - the mass of the scrap metal.
2) (5 points) What would be necessary to do next in order to find the density of the metal used to make scrap? Write down formulae with which the metal density could be determined. (Let it be noted that, apart from the graduated cylinder, there are no other measuring devises at your disposal)

14. (10 points) Three small snails are each at a vertex of an equilateral triangle of side 60cm. The first sets out towards the second, the second towards the third and the third towards the first with uniform velocity of 5 cm/min. During their motion each of them always heads towards its respective target snail. Where will the snails meet? How much time will it take them to meet and what distance will they cover till then?



V Answer the question and give an explanation

15. (2 points) Two metal balls are suspended from a stand using light isolating threads as is shown in the picture. One of the balls is known to be negatively charged. The position of the balls shown in the picture is their equilibrium position. Is the other ball charged? If so, is its charge positive or negative?



16. (3 points) Tanya And Alexander got from their teacher two seemingly identical bars. The teacher told them that one bar is a permanent magnet and that the other bar is made out of iron and is not magnetized. Their task was to determine which of the two bars is a permanent magnet.

The students successfully solved their task by placing the bars as is shown in the picture. Initially, in case (a) they noticed that the bars attracted each other. When they exchanged the positions of the bars (case (b)) they were not attracting each other anymore. Which bar (A or B) is a permanent magnet?