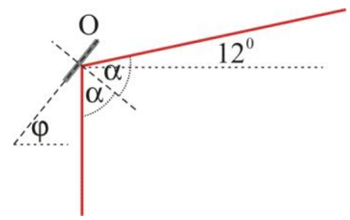
Solutions to the Physics Test

1. B
2. E
3. C
4. C
5. E
6. B
7. 1) stays constant; 2) decreases
8. 1) decreases; 2) increases
9. 1) $\mathrm{A} = \mathrm{B}$; 2) $\mathrm{A} < \mathrm{B}$
10. 1) $\mathrm{A} < \mathrm{B}$; 2) $\mathrm{A} > \mathrm{B}$
11. From the picture it follows: $2\alpha - 12^0 = 90^0$; thus $\alpha = 51^0$. The angle we are looking for is φ. It is equal to α, because its sides are perpendicular to the sides of α.



12. During the first $t = 4\,\mathrm{s}$ the bucket is accelerating upwards:

$$ma = F - mg\,; \quad a = \frac{F - mg}{m} = 0{,}25\,\mathrm{m/s}^2\,.$$

The height it reaches in that time is: $h_1 = \dfrac{at^2}{2} = 2\,\mathrm{m}$.

When the rope breaks off, the bucket has an upward velocity υ_0:

$$\upsilon_0 = at = 1\,\mathrm{m/s}\,.$$

Having this initial velocity it covers a distance: $h_2 = \dfrac{\upsilon_0{}^2}{2g} = 0{,}05\,\mathrm{m}.$

Maximum height is: $h = h_1 + h_2 = 2{,}05\,\mathrm{m}$.

From there the bucket is in a free fall. Just before it reaches the ground its velocity is:

$$\upsilon = \sqrt{2gh} = 6{,}4\,\mathrm{m/s}.$$

13.

1) If m_1 is the mass of the wooden block, in case (2) the equilibrium condition gives:

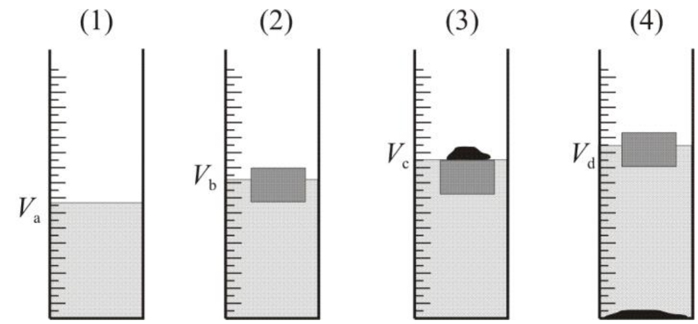
$$m_1 g = \rho_0 (V_b - V_a) g \ \ldots (*); \quad m_1 = \rho_0 (V_b - V_a) = 20 \text{ g}.$$

In case (3) the whole wooden block is submerged so we can calculate its volume and then its density:

$$V_1 = V_c - V_a; \qquad \rho_1 = \frac{m_1}{V_c - V_a} = 0{,}74 \text{ g/cm}^3.$$

If m_2 is the mass of scrap metal then the equilibrium condition in case (3) gives:

$$(m_1 + m_2) mg = \rho_0 (V_c - V_a) g; \quad m_2 = \rho_0 (V_c - V_a) - m_1 = 7 \text{ g}.$$



2) Scrap metal should be spilled in the water. Then the scale on the cylinder will show a new volume V_d (picture (4)). The equilibrium condition for the wooden block now is:

$m_1 g = \rho_0 V' g \ldots (**)$, where V' is the volume of the submerged part of the block.

From (*) и (**): $V' = V_b - V_a$.

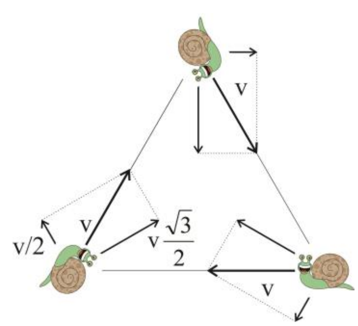
Volume V_d is equal to the sum of the volume of the water, scrap metal and the submerged part of the wooden block:

$$V_d = V_a + V_2 + V' = V_a + V_2 + V_b - V_a; \quad V_d = V_2 + V_b.$$

From there one can calculate the scrap metal volume and then its density:

$$V_2 = V_d - V_b \quad \text{and} \quad \rho_2 = \frac{m_2}{V_2}.$$

14. It is clear from the symmetry of the problem that the snails will meet at the center of the triangle (the snails stay in the vertices of an equilateral triangle which is getting smaller and rotating at the same time around its center). So then we can resolve the velocity vector of each snail as shown in the picture into two perpendicular components one of which is pointing towards the center of the triangle. We can see that the snails approach the center at constant velocities $v\sqrt{3}/2 = 5\sqrt{3}/2$ cm/min, while travelling around this point with tangential velocity $v/2$. Since the initial distance of the snails from the triangle



center is equal to the radius of the circumscribed circle which is equal to $60\sqrt{3}/3$ cm, we easily find that the snails meet in

$$\frac{60\sqrt{3}/3cm}{5\sqrt{3}/2cm/\min} = 8\min.$$

During that time each snail covers a distance of $5cm/\min \cdot 8\min = 40cm$.

15. Second ball is also negatively charged. If it were not so the balls would come closer together (that is the threads would not be vertical). In case the blue ball was not charged there would be a positive charge induced on the left side of the ball and the same amount of negative charge on the right side so there would be a net force drawing the blue ball towards the yellow one. The balls would be attracting even more if the blue ball was positively charged. (If, due to their attraction, the balls got into physical contact, the charge would cross from one ball to the other so that in the end they would both have the charge of the same sign and they would be repelling each other (so again the threads wouldn't be vertical)).

16. Bar B is a permanent magnet while bar A is not. Magnetic bar is magnetized on its ends and not in the middle. Since in case (b) there is no attraction, we conclude that neither the middle of the bar B nor the upper end of the bar A is magnetized. In case (a) there is attraction which means that the upper end of bar B attracts bar A – thus, the upper end of bar B is one of the magnetic poles (of course, the other end of the bar is the other magnetic pole).