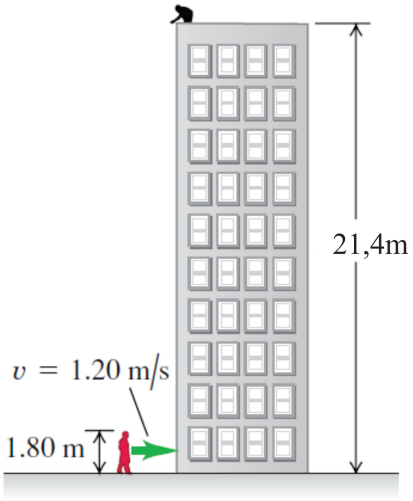
Solutions to the physics competition test

I Circle the correct answer

1. **1)** D, **2)** E - **1 point** for each correct answer

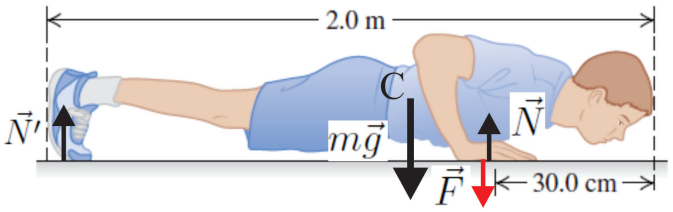
2. C - **2 points**

Egg falls freely from the roof top to the professor's head covering the distance $h = 21,4m - 1,8m = 19,6m$. Since it is falling freely, time it takes the egg to reach its target can be found from $h = gt^2/2$. Thus $t = \sqrt{2h/g} = 2s$. During that time professor was supposed to approach the entrance of the school so he had to be $l = vt = 2,4m$ away from it.



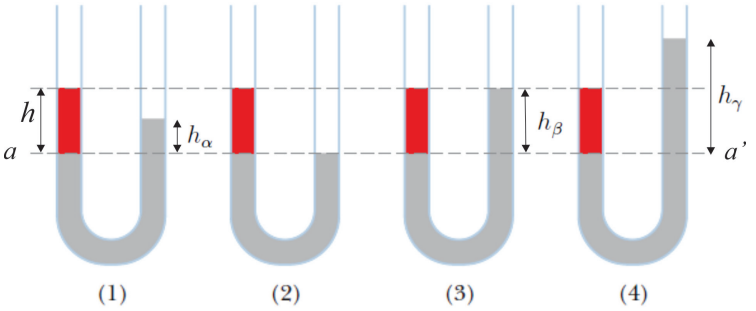
3. A - **2 points**

The picture shows all the forces acting on the volleyball player aswell as the force F with which he's pressing the floor. Since he is in equilibrium sum of all forces and torques acting on him is 0. The easisest way to find the unknown force F, which is equal in intensity and direction with the reaction force N, is to consider the balance of torques with respect to his feet which gives: $mg \cdot 1,15m = N \cdot (2m - 0,3m)$. From there $F = mg \cdot 1,15/1,7$.



4. **1)** B, **2)** B - **1 point** each

1) Looking at the pressures in the liquids on the same height $a - a'$ in both left and right arm of the U-tubes, it is obvious that the liquids in tube (2) are not in equlibrium. If they were, the pressure would be equal in both which in tube (2) is not possible. $p_{left} = p_{atm} + \rho gh \neq p_{atm} = p_{right}$ where ρ is the density of the darker liquid in the left arms of the tubes.



2) Equaling the pressures at the level $a - a'$ in left and right arms of the other three tubes we can write: for tube (1) $\rho h = \rho_\alpha h_\alpha$, for tube (2) $\rho h = \rho_\beta h_\beta$ and for tube (3) $\rho h = \rho_\gamma g_\gamma$. Since $h_\alpha < h = h_\beta < h_\gamma$ it easily follows $\rho_\alpha > \rho_\beta > \rho_\gamma$.

5. B - **1 point**

It is clear that the bar ab is a permanent magnet since it has magnetic poles even when it is far away from other magnets. That leaves us with cd, ef and gh. The key information is that ends f and g are repelling each other. If

either of the bars ef or gh were made out of soft iron they would then attract each other upon bringing them closer together. The one that is a permanent magnet would magnetize the other creating the opposite pole closest to it. Which leaves us with bar cd which is not a permanent magnet.

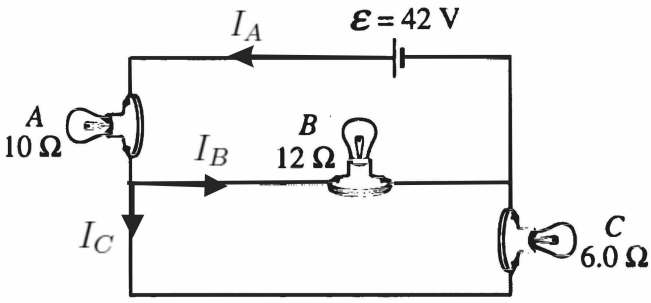
6.

1) C - **1 point**

The mirror gives a reduced, virtual image so it has to be a convex mirror because concave mirror gives a magnified virtual image.

2) B - **2 points**

Using the mirror equation we get : $-2/R = 1/p + 1/l$ where R is the radius of mirror curvature and p and l are distances of the dinosaur and its image from the mirror. Replacing numerical values gives $l = -0,5m$, so the distance of *T.rex*'s image is $|l| = 0,5m$.



7.

E - **3 points**

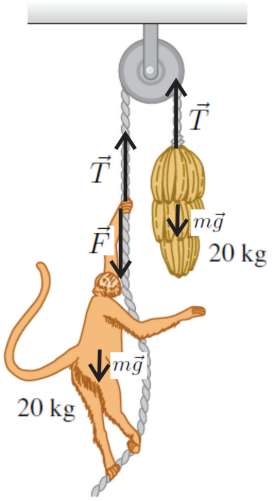
Using Kirchhoff's laws we find currents:

$$I_A = \frac{\varepsilon}{(R_A + R_B R_C/(R_B + R_C))} = 3A$$

and from $I_A = I_B + I_C$ and the fact that bulbs B and C are connected in parallel $I_B R_B = I_C R_C$ we also get $I_B = 1A$ and $I_C = 2A$. Power of the emitted light by the bulbs is proportional to the rate of energy release in the light bulb due to its resistance which we can calculate using Joul-Lenz's law. So $P \propto I^2 R$. From there it is easy to determine that $P_A > P_C > P_B$.

If any of the enequilities suggested by the student's answer was right it was marked with **1 point**.

II Fill in the blanks with: INCREASES, DECREASES or STAYS CONSTANT



8.

a) stays constant - **2 points**

If you look at the drawing the situation is clear. Monkey is pulling on the rope with force $\vec{F}$. In turn there's a reaction force from the rope $\vec{T} = -\vec{F}$. The only two forces acting on both the monkey and bananas are $\vec{T}$ and $m\vec{g}$. Newton's second law tells us that they will both start moving with the same acceleration $\vec{a} = (\vec{T} + m\vec{g})/m$. Since they both move vertically the distance between them doesn't change.

b) stays constant - **1 point**

When the monkey releases the rope both him and bananas star free falling, again with same acceleration $\vec{g}$ so the distance between them still stays constant.

9.

a) weight decreases - **1 point**

b) weight increases - **1 point**

10.

a) current decreases - **1 point**
b) current stays constant - **1 point**
c) current increases - **1 point**

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

11. $t_A > t_B$ - **3 points**

12. $T_A > T_B$ - **3 points**

IV Solve the problems

13. $v = IU/mg = 0,77m/s$ - **4 points**

14. $170cm/2 = 85cm$ - **5 points**

V Answer the question and give an explanation

15.

a) Nearsighted person should use diverging lenses, while farsighted should use converging lenses. - **3 points**
b) Glasses in picture 1) are for nearsighted people, and in picture 2) for farsighted people. - **4 points**

16. The level of water doesn't affect the easiness with which we can drink through a straw since we suck up air through the straw thus we decrease the air pressure inside it which allows it to climb up. How far up it climbs depends solely on the air pressure difference (with respect to the outside atmospheric pressure) we create. - **2 points**

It easier to drink through a straw in Belgrade because the atmospheric pressure is greater than on Mount Everest. When we decrease the pressure inside the straw the surrounding atmosphere pushes harder on the water's surface in Belgrade than on Mount Everest. - **2 points**