2011 Seagull Competition

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Problem 1. The highest mountains on Earth ($\oplus$) and Mars (σ) are 9 km (Mount Everest) and 27 km (Olympus Mons) respectively. Estimate the peak of the highest mountain on Venus ($\female$). The mass of Mars and Venus are $M_{\sigma} = 0.107 M_{\oplus}$ and $M_{\female} = 0.815 M_{\oplus}$ and their radii are $r_{\sigma} = 0.532 r_{\oplus}$ and $r_{\female} = 0.950 r_{\oplus}$.

Problem 2. The speed of a strong wind is 30 m/s. A boy throws a rock such that the drag force is proportional to the square of the relative velocity between the rock and the air. This drag force is equal to the gravitational force when the relative velocity is 30 m/s. The boy throws the stone against the wind at an initial speed of 10 m/s and the stone leaves his hand at a height of 1 m. What is the maximum range?

Problem 3. A spring and a physical pendulum are oscillating with periods of T_1 and T_2 respectively such that $T_1 = T_2$. If replicas are built such that length dimensions are increased by a factor of 4 but they are still made of the same materials as before, what is the ratio T_1/T_2?

Problem 4. Saturn (which orbits around the Sun every 29.5 years) has a moon Titan, which like Earth has an atmosphere that is composed mainly of nitrogen. The pressure on Titan's surface is 1.5 atm. What is the average surface temperature of Titan?

Problem 5. A spacecraft takes off from Earth and starts moving towards a star 10 light-years away. To make the crew comfortable, the spacecraft is moving at a constant acceleration of 10 m/s^2. How much time has elapsed for the people on Earth once the spacecraft arrives?

Problem 6. Two rings with a radius of 10 cm, located at a distance of 1 cm from each other, are connected with a soap film such that a "cylinder" is obtained. The ends of the resulting "cylinder" are not covered with a film. Thus, we are dealing with a "cylinder" with a height of 1 cm and a radius of 10 cm. If we start to move the rings apart, then at a certain distance between them, the film will burst. At what distance between the rings will this happen?[1]

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[1]Note: this problem has also appeared in the 2003 Estonian National Olympiad as well As Kalda's Thermodynamics handout.