Tyngdpunkten 2026

Easier

November 2026

Each problem is worth at most 10 points. On problems with several parts, points can be awarded for a part even if the earlier parts have not been solved. Well-justified graphical solutions are always awarded full marks. Good luck!

1. A falling physicist The 2023 Nobel laureate in physics, Anne L'Huillier,[1] rides the Free Fall drop tower at Gröna Lund. The gondola is released 80 metres up in the air and Anne then falls freely, until the magnetic brakes start acting 30 metres above the ground. For how long does she fall freely? You may neglect air resistance and friction.

2. Robyn's light bulbulbulbs

a) In the circuit that Robyn has built there are two light bulbs with the same resistance, see Figure 1. When the switch is open, the ammeter shows 0.6 A. What will the current be if the switch is closed so that the second light bulb is connected to the circuit?

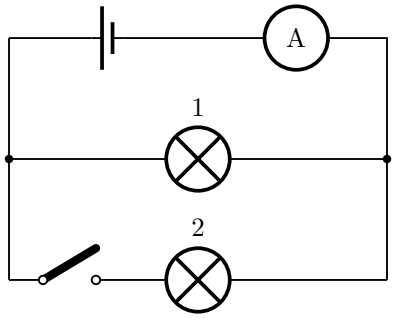


Figure 1: Robyn's circuit.

b) Robyn then replaces the light bulbs with two light bulbs with different resistances: light bulb 1, which is always connected, and light bulb 2, which is in series with the switch. When both are connected in the circuit the ammeter shows 1.0 A, and when light bulb 2 is disconnected it shows 0.7 A. The voltage of the battery is 3.5 V. What is the resistance of light bulb 2?

3. Cooking or cooked Oh no! Patrik realized that he had forgotten to turn off the hotplate when he left for work this morning. Luckily he is a physics teacher and can calculate when he has to be home at the latest before the saucepan boils dry. He knows that he had about 2 litres of water at 20 °C in the saucepan and that his hotplate supplies 1200 W. How long can Patrik be away before the saucepan boils dry? Disregard heat exchange with the surroundings as well as the heat capacity of the saucepan.

4. Japan is turning footsteps into electricity Piezoelectric power generation harnesses the energy from people's footsteps and converts it into electricity. The system works by placing floor tiles on the ground, and underneath the tiles there is a special material that generates a voltage when it is deformed. Now imagine that the entire surface of Sweden is covered by such power-generating tiles. Make reasonable assumptions and estimate how many mobile phones could be charged every day with the electricity that is produced.

Note: The points are based mainly on reasoning and justifications, not on the numerical answer.

[1] Anne L'Huillier works at Lund University as a professor of physics and received the 2023 Nobel Prize in Physics for experimental methods in which she generated pulses of light lasting attoseconds (10^{-18} s)!

5. EXO-EXOplanet When a planet passes in front of its star, as seen from Earth, it blocks a small part of the star and the brightness of the star decreases a little.[2] Figure 2 shows how the brightness of the star K2-140 varied over just under 48 days, as measured by the Kepler space telescope. In Figure 3 all the transits in Figure 2 have been superimposed so that the shape of a transit is more clearly visible. The star K2-140 has the mass $1.00\,M_\odot$[3] and the radius $0.99\,R_\odot$, where $M_\odot = 1.99 \cdot 10^{30}$ kg and $R_\odot = 6.96 \cdot 10^8$ m. Assume that the orbit of the planet is a circle and that the mass of the planet is negligible compared to that of the star.

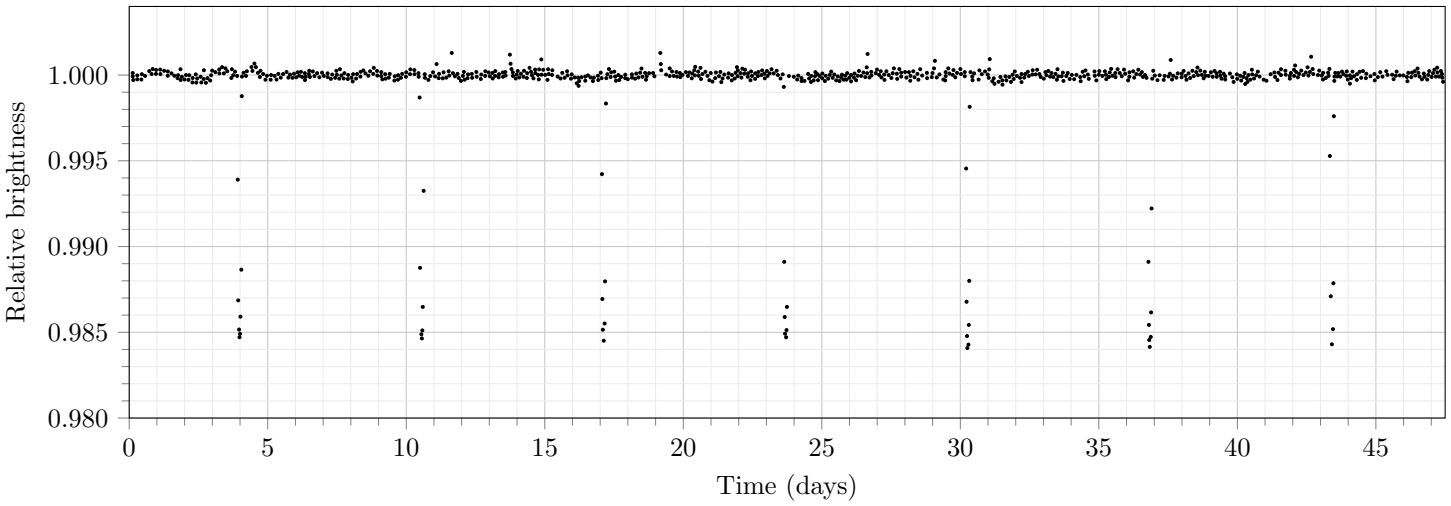


Figure 2: The relative brightness of the star K2-140 as a function of time. A brightness of 1 corresponds to the normal brightness of the star. Data: NASA, Kepler/K2.

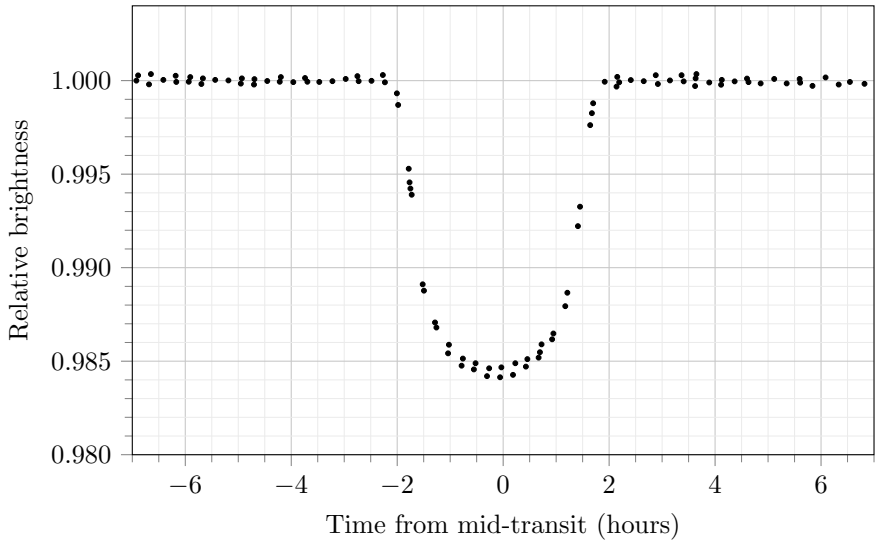


Figure 3: All transits from Figure 2 superimposed, as a function of the time from mid-transit.

a) Determine the orbital period of the planet.

b) Determine the distance from the planet to the star.

Hint: Kepler's third law gives $\dfrac{T^2}{a^3} = \dfrac{4\pi^2}{GM}$, where T is the orbital period, a is the distance to the star and M is the mass of the star.

c) Determine the radius of the planet. Compare with the radius of the Earth, $R_\oplus = 6.37 \cdot 10^6$ m.

[2] This is called a *planetary transit* and is the most common way of finding planets around other stars, so-called exoplanets.

[3] $M_\odot$ is an astronomical notation for the mass of the Sun. K2-140 is thus very similar to our Sun; the question is whether the planet is also very similar to our Earth...

6. Imaging Dragons Technetium-99m and fluorine-18 are two radioactive isotopes that are used in medical imaging. Technetium-99m has a half-life of 6.0 hours, while fluorine-18 has a half-life of 110 minutes. A sample from a patient contains both substances, but in unknown proportions. To find out the proportions, two measurements are made. Immediately after the sample has been taken, the total activity is measured to be 800 kBq. After 40 minutes the activity is measured again and is then 670 kBq. What were the proportions of technetium-99m and fluorine-18, respectively, in the original sample, in terms of the number of atomic nuclei?

7. Neutron + star = true Normally, free neutrons decay according to the following reaction:

$$n \to p^+ + e^- + \bar{\nu}_e$$

In neutron stars the pressure is so high that this reaction cannot take place. Because of the very strong gravity, another reaction takes place instead, something called electron capture:

$$p^+ + e^- \to n + \nu_e$$

The masses of the proton, the neutron and the electron are $m_p = 1.007276$ u, $m_n = 1.008664$ u and $m_e = 0.00054858$ u. The mass of the neutrino is not known exactly, but lies somewhere between 0 and $5 \cdot 10^{-10}$ u.[4] Calculate the smallest possible speed that an electron must have for electron capture to be able to take place, given that the proton is at rest.

Hint: At these speeds, the relativistic formula for kinetic energy must be used:

$$E_k = \left(\frac{1}{\sqrt{1 - v^2/c^2}} - 1 \right) mc^2.$$

8. Lifting lids and lid lifting In the classroom, the physics teacher Nisse has brought out a container consisting of an open-topped cylinder with height 30 cm and diameter 10 cm. The container contains nothing but air. On top of the cylinder Nisse places a tight-fitting lid that weighs 0.5 kg. The lid rests freely on top of the cylinder, that is, it is not attached in any way. Initially the temperature of the air inside the container is 20 °C, the same as in the rest of the classroom, and then Nisse starts heating it. The air pressure in the classroom is 101.3 kPa.

a) At what temperature does the container start leaking air?

b) Nisse continues heating until the air in the container has the temperature 80 °C. Then he stops heating and waits until the air has cooled to 20 °C again. How large a force is now required to lift the lid?

9. The sliding wedge A block with mass 1.0 kg is released from rest on a wedge with mass 2.0 kg and inclination angle 30°. The wedge stands on a floor and can move freely. All surfaces are frictionless. How long does it take for the block to slide 1.0 m along the surface of the wedge?

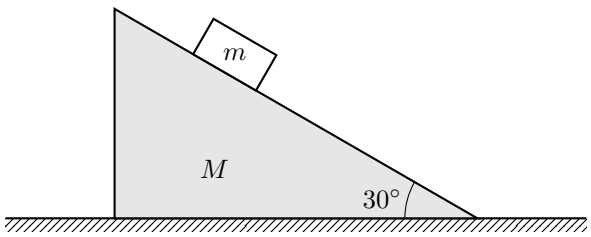


Figure 4: The block slides down the wedge, which can move freely along the floor.

[4]For a long time it was believed that neutrinos have no mass. In 2015, Takaaki Kajita and Arthur B. McDonald received the Nobel Prize in Physics for showing that neutrinos can change between different flavours, something that is only possible if they have mass. Exactly how large the mass is is still not known.

10. Astronomical resistance Stars are Nico's great passion, and to honour them he has made a star out of resistors that all have the resistance R, see Figure 5. The star is thus a complete graph with 5 vertices, where each edge is a resistor with the resistance R. What is the resistance between two of the vertices of the pentagon, for example between A and B?

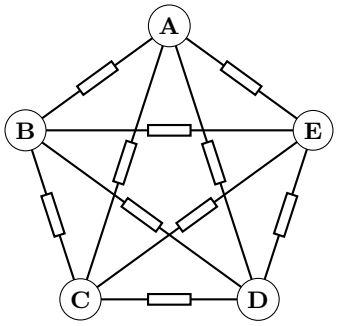
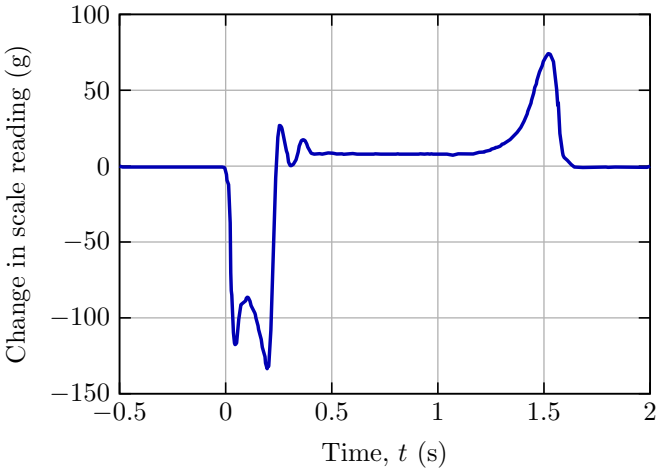


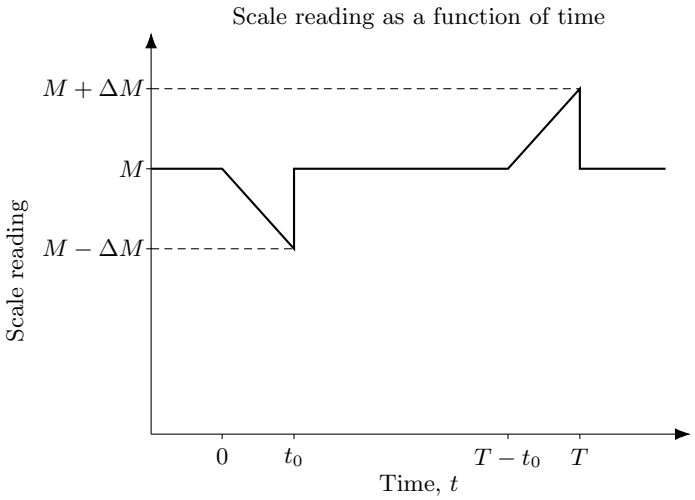
Figure 5: Nico's star.

11. Grains of sand with a big impact An hourglass stands on a very precise kitchen scale with all the sand in the lower half. At $t = 0$ the hourglass is quickly turned upside down. All the sand then ends up in the upper half and starts flowing down through the narrow neck. Figure 6a shows how the scale reading changes when this is done in a real experiment. Figure 6b shows a simplified model of the same process, where T is the time when the last grains of sand reach the bottom. The hourglass with sand has total mass M and height $2h$. The neck is in the middle, i.e. at height h above the bottom. The sand flows through the neck at the constant mass flow rate Q (unit kg/s). Make the following assumptions:

- Sand that has not yet passed the neck is at rest.
- The sand's volume is small compared to the hourglass's. All sand therefore falls the full distance h to the bottom.
- Air resistance is negligible, and the grains of sand stop completely when they hit the bottom.



(a) Measured change in the scale reading (in grams) when the hourglass is turned at $t = 0$. Source: A. Sack and T. Pöschel, *Am. J. Phys.* **85**, 98 (2017).



(b) Simplified model of the scale reading. The reading is M before the hourglass is turned and after all the sand has landed.

Figure 6: The scale reading as a function of time when an hourglass is turned upside down.

a) Explain qualitatively, i.e. without calculations, why the graph in Figure 6b looks the way it does. Describe what happens to the sand, and how it affects the scale reading, during each of the time intervals $0 < t < t_0$, $t_0 < t < T - t_0$ and $T - t_0 < t < T$. Also explain why the reading changes abruptly at $t = t_0$ and $t = T$.

Hint: The scale measures the normal force N with which the hourglass presses on it and shows the mass N/g. Also think about what is required to stop the sand that hits the bottom.

b) Determine t_0 and ΔM in terms of (some of) the quantities M, h, Q and g. Also show that the scale shows exactly M for $t_0 < t < T - t_0$.

Hint: Consider a small mass of sand $\mathrm{d}m = Q\,\mathrm{d}t$ that reaches the bottom during a short time $\mathrm{d}t$.