Høsten 2019

FYS100 Fysikk: Hand-in II

To be handed in at the latest **Friday 30th August 2019, at 23.59**.
You **must** hand it in by scanning your handwritten solution or compiling your electronic documents into **a single .pdf** file, and uploading it to Canvas in "Week Two Exercises". Bad mobile phone pictures are not acceptable (there are apps that work OK), nor are any other file formats than a single .pdf.

You **must**:

- Put your name and student number on each page.
- Make sketches for all problems, where it makes sense.
- Write in a readable, well-structured way.

Pass is 40% correct (including partial credit). There is no grade. There is **no option** to correct and resubmit.

Good luck!

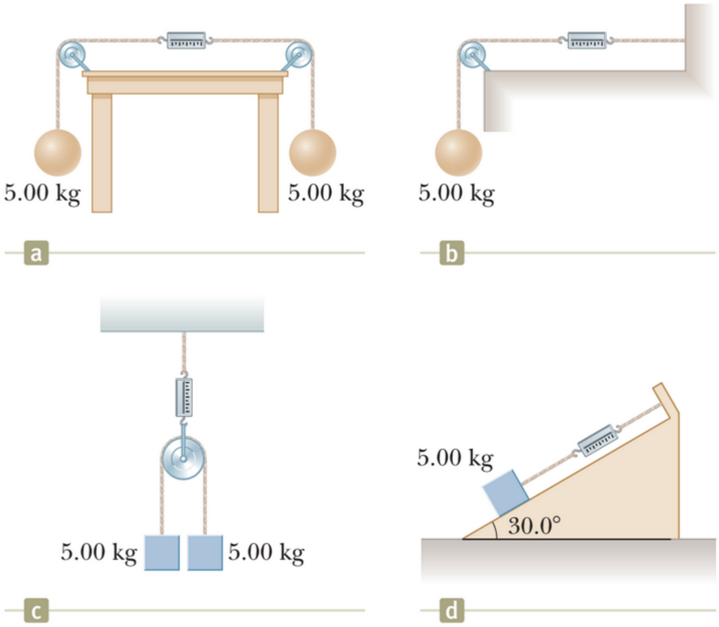

Figure P5.28

Problem 1: Static equilibrium (5.28 in the book)

The systems shown in Figure P5.28 are in equilibrium. If the spring scales are calibrated in Newtons, what do they read? Ignore the masses of the pulleys and strings and assume the pulleys and incline in Figure P5.28d are frictionless.

Solution (One mark for each part): Do b) first. It must be $|\mathbf{F}| = 5 \times 9.82 = 49.1$ N, to cancel gravity. Then take a) and imagine grabbing the horizontal rope: that reduces a) to two times b) where the tension must be constant along the whole rope. So that shows 49.1 N. In c), it has to hold up both masses, so 98.2N. And finally in d), the spring has to compensate the component of gravity along the plane, which is $mg \sin\theta = 24.6$ N.

Problem 2: Forces on slopes

A child of mass 15.0 kg slides on a children's slide. The coefficient of kinetic friction between the slide and the child in dry conditions is 0.500.

a) Find the angle that the slide would have to make with the horizontal for the child not to accelerate as they move down the slide.

Solution: Use Newton's second law and resolve the forces parallel and perpendicular to the slope.

Perpendicular component: $N - W\cos\theta = 0$

Parallel component: $W\sin\theta - f_k = 0$ (Acceleration is required to be zero along the slope.)

Use $f_k = \mu_k N$ (Child is moving but not accelerating.)

$\implies \theta = \tan^{-1}\mu_k = 26.6°$ (3 sig. fig.)

b) The slide is constructed with an angle of 45° to the horizontal and is 2.0m long. The child starts from rest at the top of the slide. How long does it take the child to reach the bottom of the slide?

Solution: As above, use Newton's second law and resolve the forces parallel and perpendicular to the slope.

Perpedicular component: $N - W\cos\theta = 0$

Parallel component: $W\sin\theta - f_k = ma$ (Now the acceleration is non-zero.)

Use $f_k = \mu_k N$ and $s = ut + \frac{1}{2}at^2$ where $u = 0$ because the child starts from rest.

$\implies t = \sqrt{\frac{2s}{a}}$, the distance is $s = 2.0$m and from Newton's second law above, $a = g(\sin\theta - \mu_k\cos\theta) = 3.47\text{ms}^{-2}$

$\implies t = \sqrt{\frac{2*2.0}{3.47}} = 1.1$s (2 sig. fig.).

c) At the bottom, the slide continues horizontally. How far does the child travel along this horizontal portion before coming to a stop?

Solution: First find the speed at the bottom of the slope. Use $v = u + at$ and $u = 0$ and the values of a and t from above. Speed at end of slope $= 3.47*1.1 = 3.7\text{ms}^{-1}$.

Along the horizontal section the frictional force is different, because the normal force is different. So the acceleration is now $a_{horizontal} = \mu_k g = 0.500 * 9.82 = 4.91\text{ms}^{-2}$.

Then use $v^2 - u^2 = 2as$ where the final velocity $v = 0$, the intial velocity u is the velocity at the end of the slope and a is the horizontal acceleration $a_{acceleration}$ from above.

$s = \frac{u^2}{2a} = \frac{3.7^2}{2*4.91} = 1.4$m.

d) After some rain, the slide is wet and the coefficient of kinetic friction is reduced. Will it take longer or shorter for the child to travel from rest at the top of the slide to the bottom of the slide, compared to dry conditions? Will it take longer or shorter for the child to come to rest along the horizontal section compared to dry conditions? Explain your answers.

Solution: It will take a shorter amount of time to slide down theinclined part of the slide because the friction is reduced and thus the acceleration is higher and the child reaches the bottom sooner. It will take longer to come to rest along the horizontal section because again the friction is lower and so the deceleration is lower.

One mark each for parts a and b. Two marks each for parts c and d.

Problem 3: Newton's third law

An apple of mass 0.1 kg falls from a tree to the ground 2.0m below.

a) How long does it take the apple to hit the ground?

Solution Use kinematic relation $s = ut + \frac{1}{2}at^2$ and the acceleration due to gravity (in Stavanger) $a = 9.82\text{ms}^{-2}$.

$t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2*2.0}{9.8}} = 0.638 = 0.64s$ (2 sig fig).

b) During the fall, what magnitude of force does the apple exert on the Earth?

Solution By Newton's third law the magnitude of force exerted by the apple on the Earth is the same as the magnitude of force exerted by the Earth on the apple $= mg = 0.1 * 9,8 = 1.0\text{N}$.

c) Approximately how far does the Earth move towards the apple during the fall?

Solution Use $s = ut + \frac{1}{2}at^2$. The time taken is the same as for the apple to fall and the acceleration $a = F/m$ where the force is as above and m is the mass of the Earth (from the book or internet $m = 6 * 10^24\text{kg}$).

$s \sim 10^{-26}\text{m}$ (The numbers I use give $3.35 \times 10^{-26}\text{m}$ but an approximate order of magnitude estimate is all that is required here.)

d) During the fall, is the apple moving, the Earth moving, or both, or neither? Explain your answer.

Solution In theory both the apple and Earth are moving, but the Earth moves a tiny amount (much less than the radius of a proton) and this is completely unmeasurable with current technology.

One mark each for parts a, b and c. Two marks for part d.

Total marks 4+6+5=15. 6 marks needed for approved.