Høsten 2019

FYS100 Fysikk: Hand-in IV

To be handed in at the latest **Friday 13th September 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 Four 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!

Problem 1: Work done

A 63kg skier coasts down a 30° slope. At the top of the slope her speed is 3.6m/s. She accelerates down the slope because of the gravitational force, even though a frictional force of magnitude 71N opposes her motion. The slope has a length of 83m.

a) What is the work done by the frictional force on the skier over the slope?

Solution: The frictional force acts in the opposite direction to the skier's displacement, so the work done is negative. Use $W_{fric} = Fd = 71 * 83 = 5893$J, so the work done on the skier by friction is -5900J (2 sig.fig.).

b) What is the work done by the gravitational force on the skier over the slope?

Solution: The component of the gravitational force along the slope is $mg\sin\theta$ and acts in the same direction as the displacement. So $W_{grav} = mg\sin\theta d = 63 * 9.82 * \sin 30 * 83 = 25674.39$J, so the work done by gravity is +26000J (2 sig. fig.)

c) What is the speed of the skier at the bottom of the slope?

Solution: The change in the kinetic energy is equal to the net work done on the skier. $\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = W_{grav} + W_{fric}$. So $v_f = \sqrt{v_i^2 + 2(W_{grav} + W_{fric})/m} = \sqrt{3.6^2 + 2 * (26000 - 5900)/63} = \sqrt{647} = 25.45 = 25$m/s (2 sig. fig.)

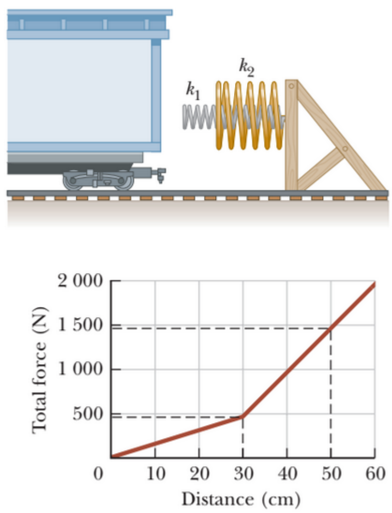

Figure P7.59

Problem 2: Hooke's Law and work done (7.59 in the book)

A 6000-kg freight car rolls along rails with negligible friction. The car is brought to rest by a combination of two coiled springs as illustrated in Figure P7.59 above. Both springs are described by Hooke's law and have spring constants $k_1 = 1600$ N/m and $k_2 = 3400$ N/m. After the first spring compresses a distance of 30.0 cm, the second spring acts with the first to increase the force as additional compression occur as shown in the graph. The car comes to rest 50.0 cm after first contacting the two-spring system. Find the car's initial speed.

Solution: There are different ways to do this problem. The easiest way is to use the graph and the fact that work done is equal to the area under the curve since $W = \int F.dr$. The area under the curve can be read off from the graph as $75 + 100 + 100 = 275$J. Since we assume that all the kinetic energy of the car goes into doing work on the spring, we can set $\frac{1}{2}mv^2 = W$ and $v = 2 * 275/6000 = 0.303 = 0.30$m/s to 2 sig. fig. The book gives the answer as 0.299m/s and the answers are the same to two significant figures.

Problem 3: Gravitational Potential Energy

The new town hall in Sandnes has a flat roof whose area is approximately 2500m^2. The average annual rainfall in Sandnes is 1400mm per year.

a) Calculate the average volume of rain that falls on the town hall in one year. Use (look up) the density of water to calculate the mass of this water.

Solution: The volume is the height of water times the area of the roof $= 1.4 * 2500 = 3500$m^3. Density of water is 1000kg/m^3. So total mass is 3,500,000kg.

b) Assume the roof of the town hall has a height above the sea level of 17m. What is the total gravitational potential energy (relative to the sea) of the average annual rainwater that falls on the roof of the town hall?

Solution: Gravitational potential energy is mgh. (Assume here that the water is collected on the surface of the roof and does not accumulate.) So PE$= mgh = 3500000 * 9.8 * 17 = 584290000 = 580,000,000$J (or 580MJ).

c) If 100 percent of this potential energy could be turned into electricity, calculate how much electrical energy this would be in kilowatt hours (one Watt equals one Joule per second).

Solution: 1kW is 1000 Joules per second, so 3,600,000 Joules per hour. One kilowatt hour is therefore 3,600,000 Joules (or 3.6MJ). So total energy is 580/3.6=161kWh.

d) In practice, only around 50 percent of the potential energy can be converted into electricity for low flow rates. If Lyse sells electricity at 50 øre per kWh, what would be the value in kroner of the rain that falls on the roof of Sandnes town hall in one year? Is it likely to be worthwhile collecting the rain from the roof to turn it into electricity?

Solution: Total energy of electricity generatable is $161 * 0.5 = 80.5$kWh. So total value is $80.5 * 0.5 = 40, 25 = 40$ kroner to 2 sig. fig.. It is unlikely to be worthwhile, because installing and maintaining the generators would cost much more than this.