# General Physics II: Tutorial Material 6

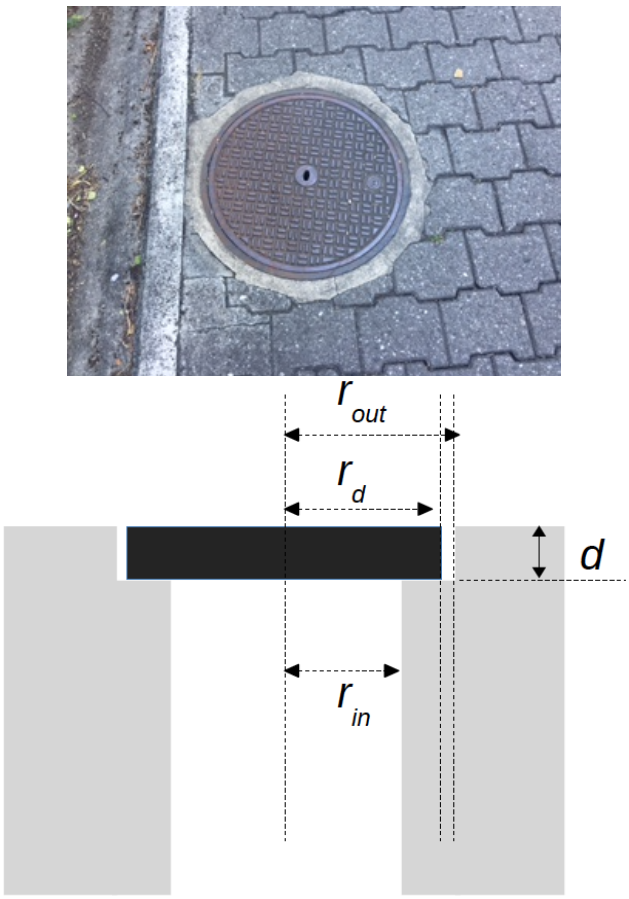
1) When the change of volume, $\Delta V$, with respect to a change of temperature, $\Delta T$, is given by $\Delta V = \beta \cdot \Delta T \cdot V_0$, where $\beta$ is the coefficient of volume expansion and $V_0$ is the initial volume, show that the change in the density is given by $\Delta\rho \approx -\beta \cdot \Delta T \cdot \rho_0$.

2) Determine formulas for the changes in the surface area and volume of a uniform solid sphere of a radius of $r_0$ if its coefficient of linear expansion is $\alpha$ and its temperature is changed by $\Delta T$.

3) There is an aluminium square plate ($100\ \text{cm} \times 100\ \text{cm}$) at $0^\circ\ \text{C}$ with a hole in the centre with a radius of 10 cm. If we heat the plate to $500^\circ\ \text{C}$, what will be the size of the plate and how large will be the whole in the centre? Note that the coefficient of linear expansion for the aluminium is given by $25 \times 10^{-6}$, coefficient of volume expansion $75 \times 10^{-6}$.

4) A concrete manhole on a road, shown in a photograph below, has an opening that can be closed with a metal disk so that the road surface remains practically even, as illustrated in the figure below showing the side view of the hole. For a given radius, $r_d$, of the metal disk, $r_{in}$ should be maximised for the comfort of the people who go down the hole and $r_{out}$ must be minimized to reduce the cost. The metal disk has a radius of $r_d = 50\text{cm}$ and thickness $d = 2\text{cm}$ at $20^\circ C$ and the manhole should be operational, i.e. the disk closes the manhole and the surface practically stays even when placed in the centre, between $-40^\circ C$ and $40^\circ C$. (*)

   1. For this problem, we take the linear coefficients for thermal expansion for the metal and concrete to be $10^{-3}/^\circ C$ and $5 \times 10^{-4}/^\circ C$, respectively. Calculate $r_{in}$ and $r_{out}$ when it is constructed at $20^\circ C$.
   2. The Young's Moduli for the metal and concrete are $200 \times 10^9\ N/m^2$ and $20 \times 10^9\ N/m^2$, and the compressive strength $550 \times 10^6\ N/m^2$ and $20 \times 10^6\ N/m^2$, respectively. Temperature in the morning was $35^\circ C$ and the manhole, with the dimension defined above, was closed properly. In the afternoon, the temperature reaches to $45^\circ C$. What will happen to the manhole?




5) Calculate the density of nitrogen at STP using the ideal gas law. Note that the nitrogen atom has Z= 7 and A = 14 and the nitrogen gas molecule is $N_2$.

6) A storage tank contains 21.6 kg of $N_2$ gas at an absolute pressure of 3.85 atm. What will be the pressure if the nitrogen is replaced by an equal mass of $CO_2$ at the same temperature?

7) A space ship enters in the earth atmosphere with a speed of 10km/second. Atmosphere molecules (assume nitrogen) then strike the nose of the space ship with this speed. What is the corresponding temperature? Note that the mass of one nitrogen atom is $2.3 \times 10^{-26}$kg,