General Physics II: Tutorial Material 7

1) A helium-filled balloon escapes a child's hand at sea level where the atmosphere is in 1 atm and 20.0° C. When it reaches an altitude of 3600 m where the temperature is 5.0° C and the pressure 0.68 atm, how will its volume compare to that at the sea level.

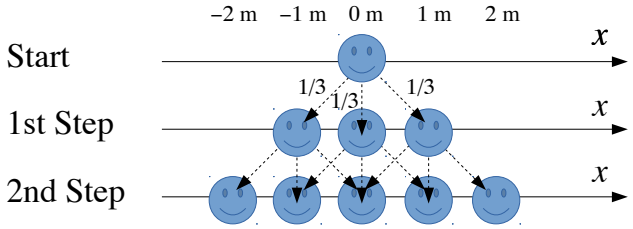
2) An air bubble with a diameter of 3.60 mm was created at the bottom of the lake, which is $d_{\text{watter}} = 2.5$ m deep. When the bubble reached the surface of the lake, where the temperature is 27° C, the diameter of the air bubble became 4.00 mm. The pressure of the atmosphere at the surface of the lake was 1 atm. What is the temperature of the water at the bottom of the lake? The density of the water is $\rho_{\text{W}} = 1\times10^{3}$ kg/m^{3} and the gravitational acceleration constant $g = 9.80\,\text{m/s}^{2}$, and assume that the air behaves as an ideal gas. (*)

3) The rms speed of molecules in a gas at 20.0° C is to be increased by 2.0%. To what temperature must it be raised?

4) If you double the mass of the molecules in a gas, is it possible to change the temperature to keep the velocity distribution from changing? If so, how much change do you need to make to the temperature?

5) There are four coins with two faces, head and tail. Each coin has 50% probability to show head and 50% probability to show tail, when tossed individually. When we toss the four coins together:
a) How many head-tail configurations are there if we can distinguish individual coins? What are the probabilities for those configurations?
b) How many head-tail configurations are there if we cannot distinguish individual coins? Which configuration has the highest probability to be realised?

6) A drunken person is standing at $x = 0$ m. When the drunken person makes one step, the person may go to the left (negative direction in x by 1m), remain at the same position or to the right (positive direction in x by 1 m) with a same probability (1/3 for each).



a) What is the probability for the drunken person to be at x = −8 m, −7 m, −6 m, −5 m, −4 m, −3 m, −2 m, −1 m, −0 m, 1 m, 2 m, 3 m, 4 m, 5 m, 6 m, 7 m and 8 m after 1, 2, 4 and 7 steps?
b) What are the mean value, $\langle x \rangle$, and rms, x_{rms}, for x after 1, 2, 4 and 7 steps?

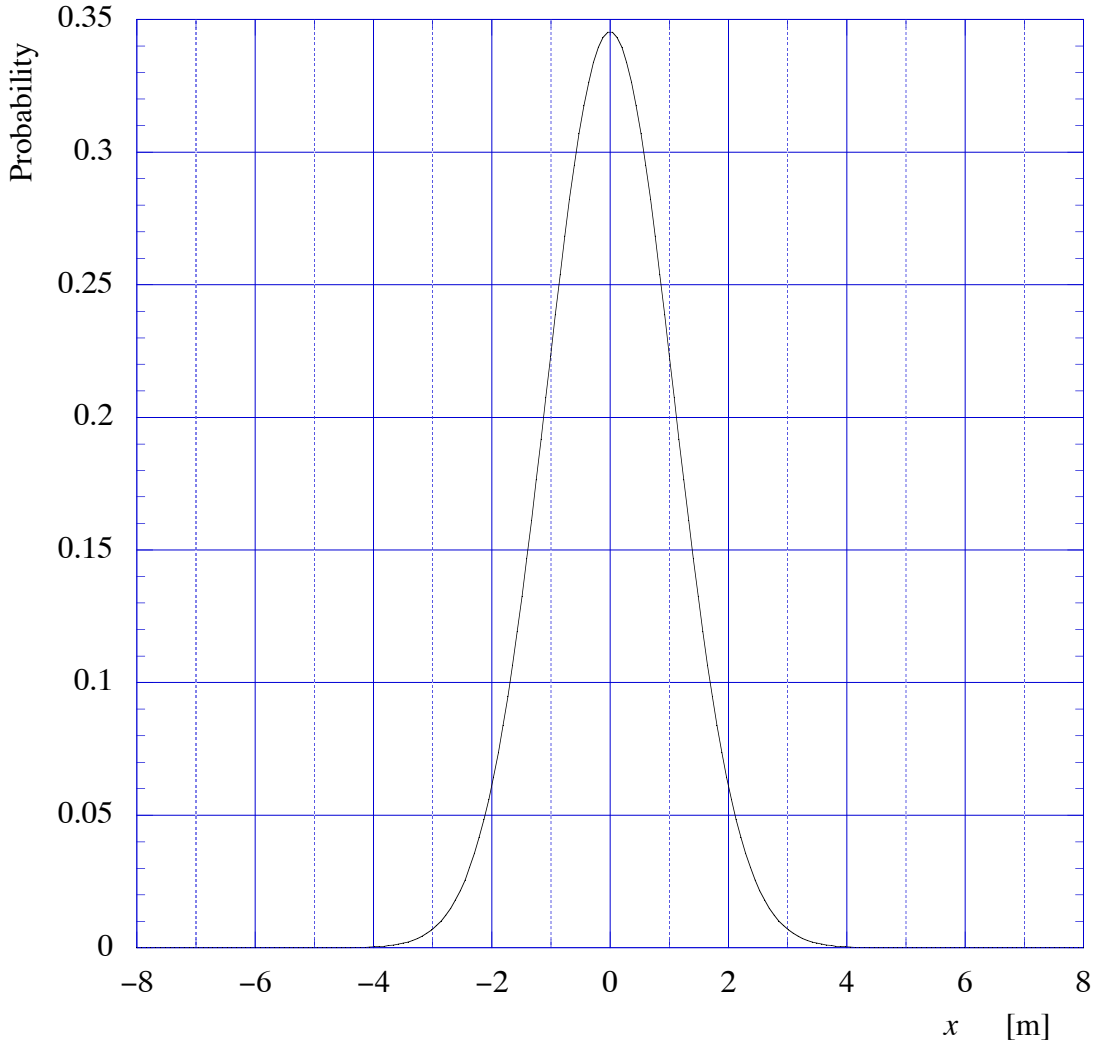
Plots below give four probability distributions in x following the Gauss distribution, $G(x)$, given by

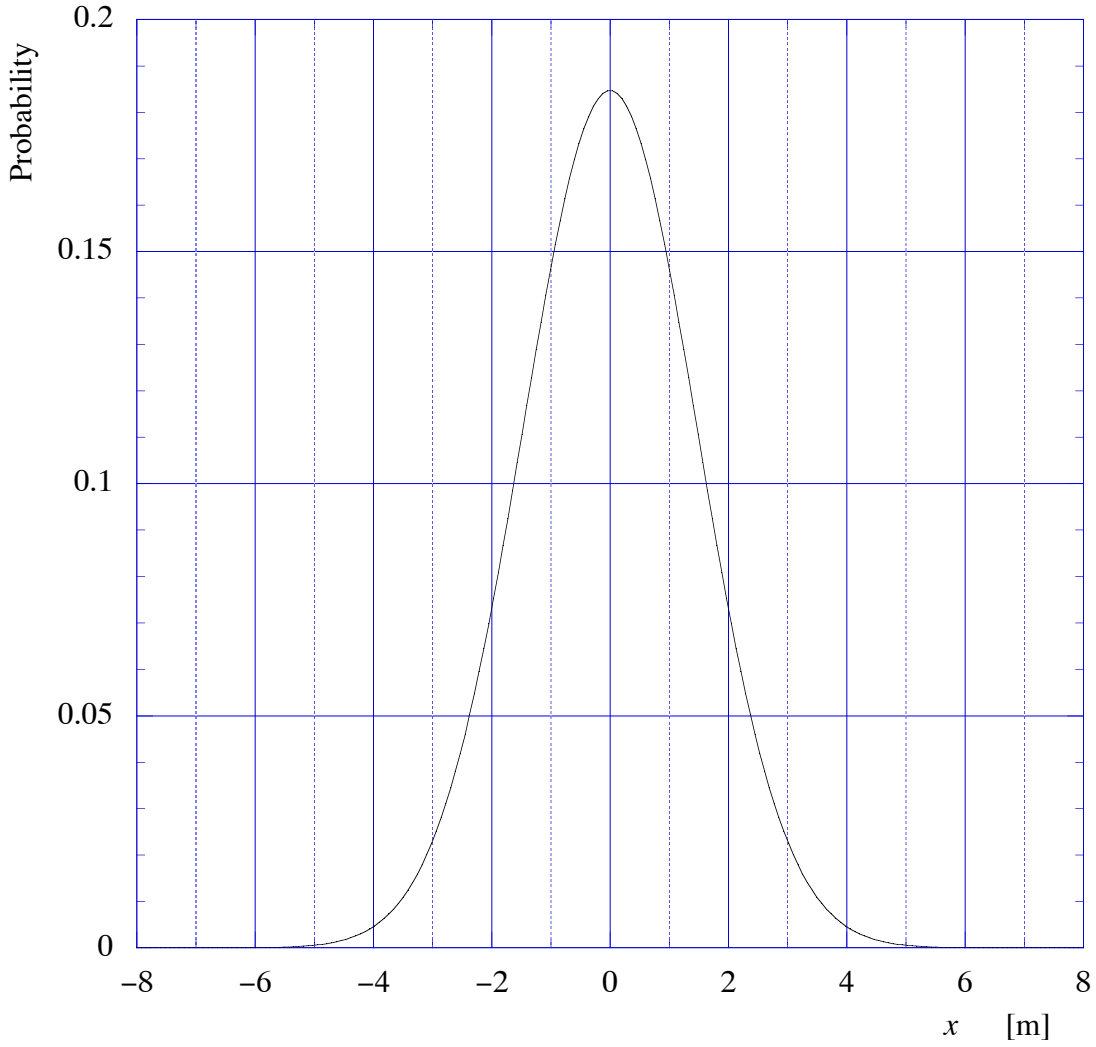
$$G(x) = \frac{1}{\sqrt{2\pi x_{\text{rms}}^2}} \exp\left[-\frac{\left(x - \langle x \rangle\right)^2}{2x_{\text{rms}}^2} \right]$$

with x_{rms} equal to those obtained for 1, 2, 4 and 7 steps above, but not necessarily in this order.

c) Find out which Gauss distribution belong to which steps.

d) Superimpose the probability distributions of the x position of the drunken person on the Gauss distribution of corresponding steps. What kind of conclusion can you draw from comparing the distributions?


Probability
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
−8
−6
−4
−2
0
2
4
6
8
x
[m]


Probability
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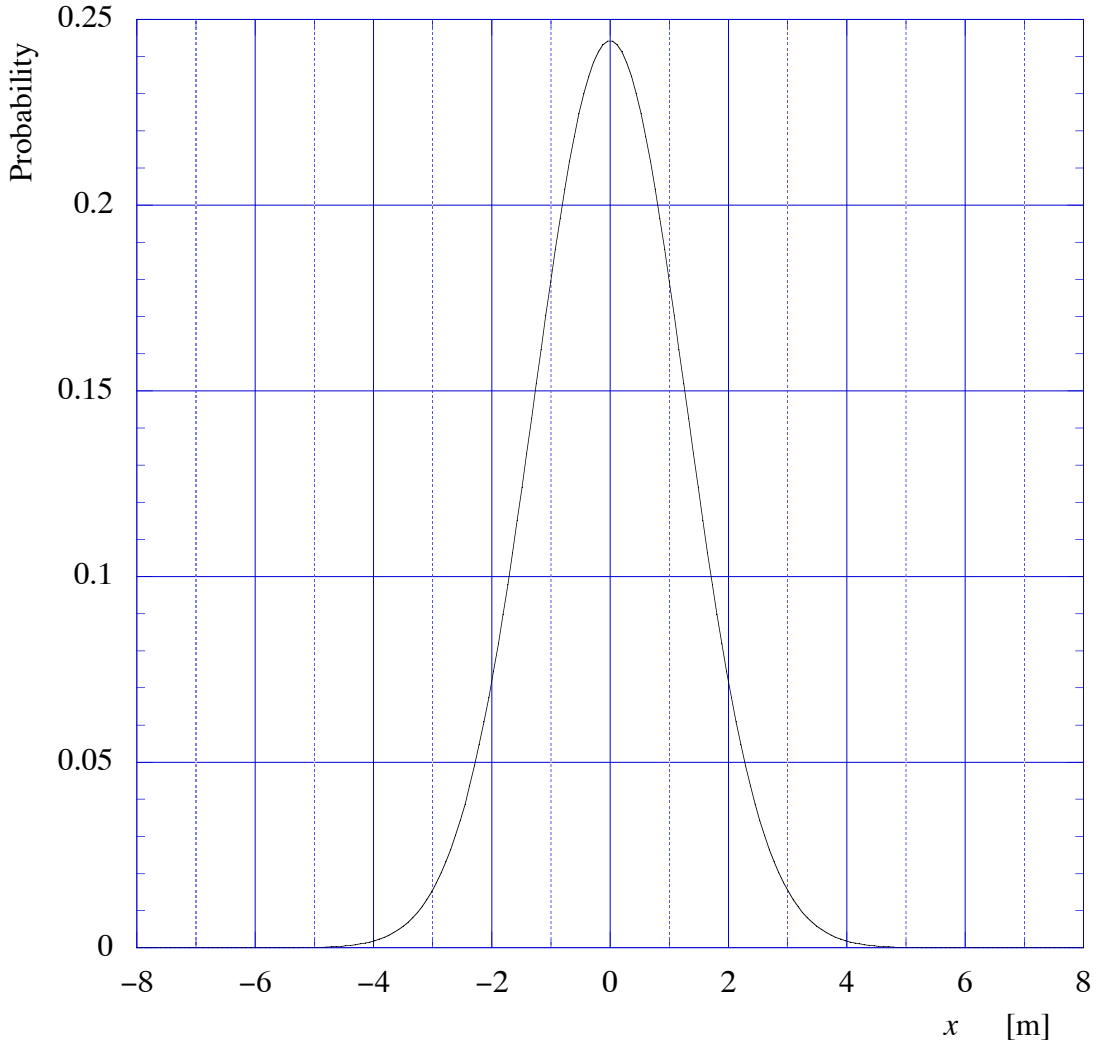
Probability
0.25
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x
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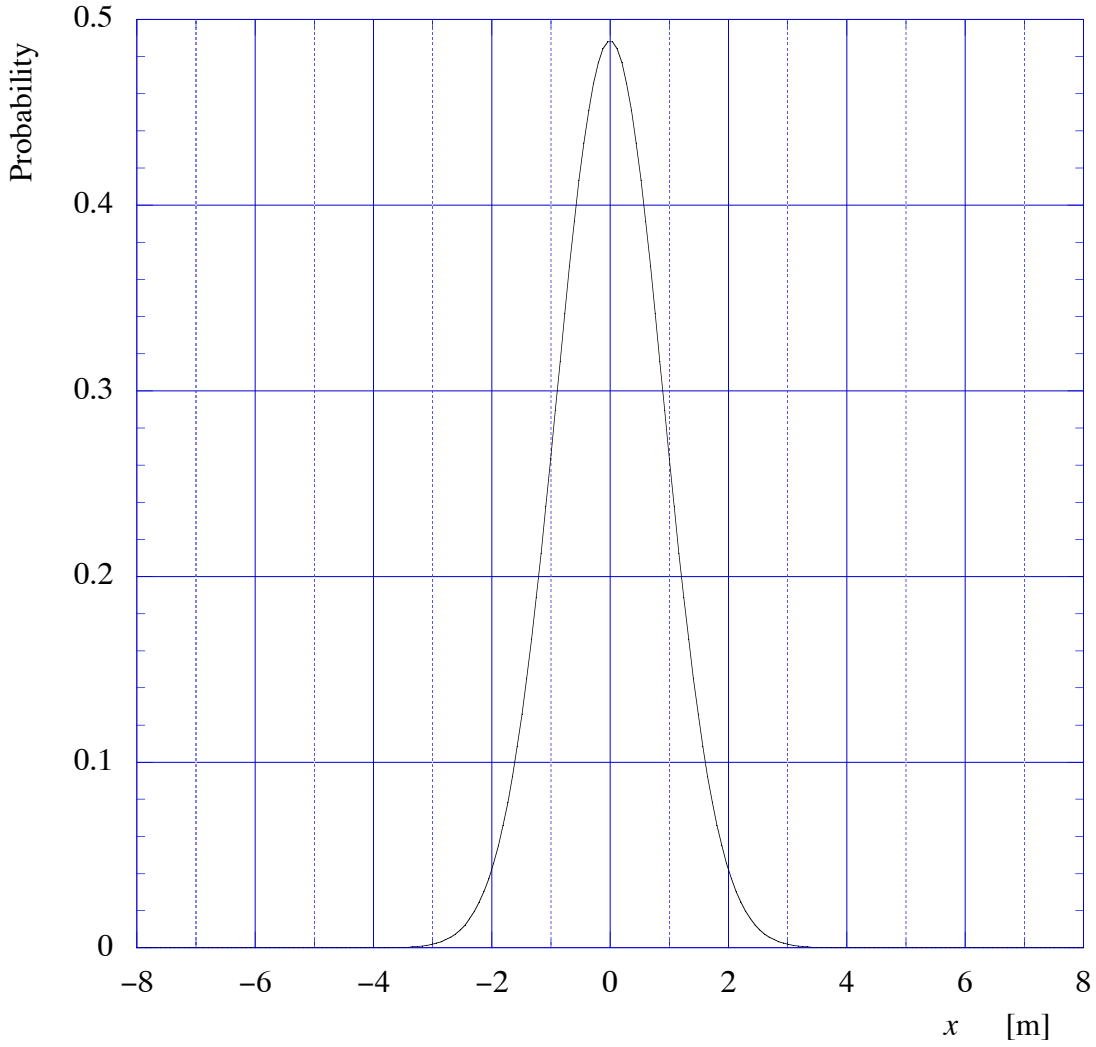
Probability
0.5
0.4
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0.2
0.1
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−8
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8
x
[m]