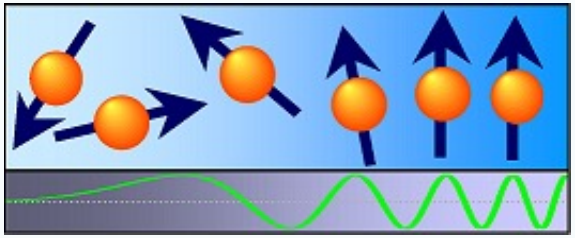
Experimental Physics
EP1 MECHANICS

- Introduction -



Rustem Valiullin

https://www.physgeo.uni-leipzig.de/en/fbi/applied-magnetic-resonance

Lecturer: Rustem Valiullin
#508, Tel. 341 97 32 515
valiullin@uni-leipzig.de

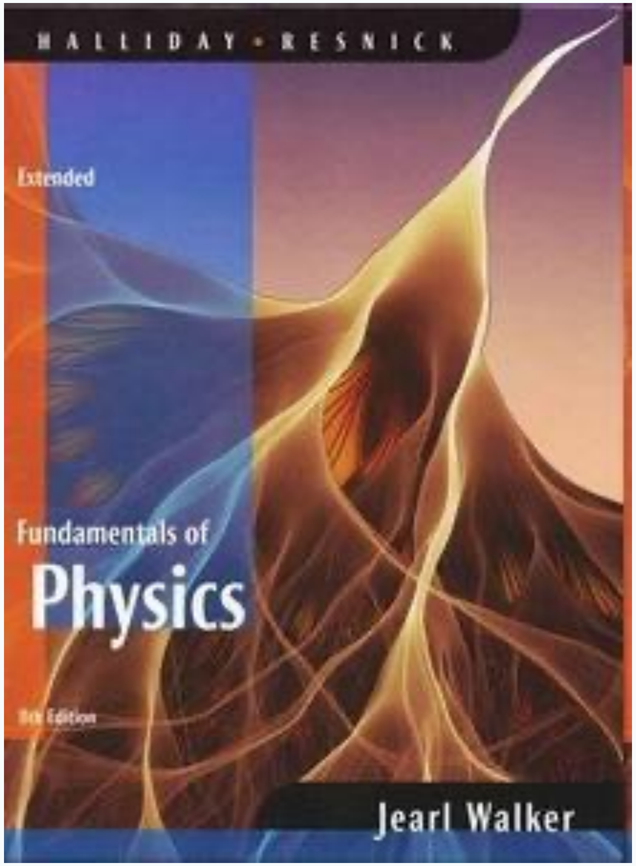
Teaching assistant: Ricardo Rose

Tutors:

Demonstrations: Friederike Pielenz

Content

Bibliography



Fundamentals of Physics
8th edition
D. Halliday, R. Resnick, J. Walker

Kompaktkurs Physik
H. Pfeifer, H. Schmiedel, R. Stannarius

On your choice
Any Author, Many Authors

Problems

1. You throw an apple upwardly at an angle of 20° to the vertical axis and then catch it at the same height, but 5 m apart from the initial position. Find the work done by the gravity force? (**1 point**)

2. Upon colliding elastically, two bodies with the masses m and $2m$ are moving in the opposite directions with the speeds $2v$ and v, respectively. Find the velocity of the center-of-mass of the system before the collision. (**1 point**)

8. Find the oscillation frequency of a harmonic oscillator made of a mass m attached to two springs connected serially. The spring constants are k_1 and k_2. (**2 points**)

11. A solid disc rolling on a table collides elastically with a massive wall. Find the translational velocity of the disc after the collision when it starts to roll again. The initial velocity of the disc is v_0. (**4 points**)

12. Two thin rods (each of a mass m and a length l) are connected at one end in a way, that they are perpendicular to each other (see Figure 2(a)). Let us call it an 'imperfect boomerang'. It lies on a frictionless surface. During a short interval of time, it is given a pulse p at the end of one of the rods perpendicular to it (see Figure 2(a)). Find:

   (a) the velocity v_{cm} of the center of mass of the boomerang (**2 points**)

   (b) the angular velocity ω_b of rotation of the boomerang about its center of mass (**5 points**)

Dimensional analysis

Length - **L** Mass - **M** Time - **T**

Density $$\rho \equiv \frac{m}{V}$$ $$[\rho] = \frac{M}{L^3}$$

Velocity $$\upsilon = \frac{x}{t}$$ $$[\upsilon] = \frac{L}{T}$$

$$x \propto \upsilon^n t^m$$ $$[\upsilon^n t^m] = L = \left(\frac{L}{T}\right)^n T^m = L^n T^{m-n}$$

n=1 $\Rightarrow$ m=1 $$x \propto \upsilon^1 t^1$$

Measurements error

$$x_r$$ - real value of a (non-quantized) physical value

$$x_i$$ - measured value of the physical value

$$\left| x_i - x_r \right|$$ - absolute error

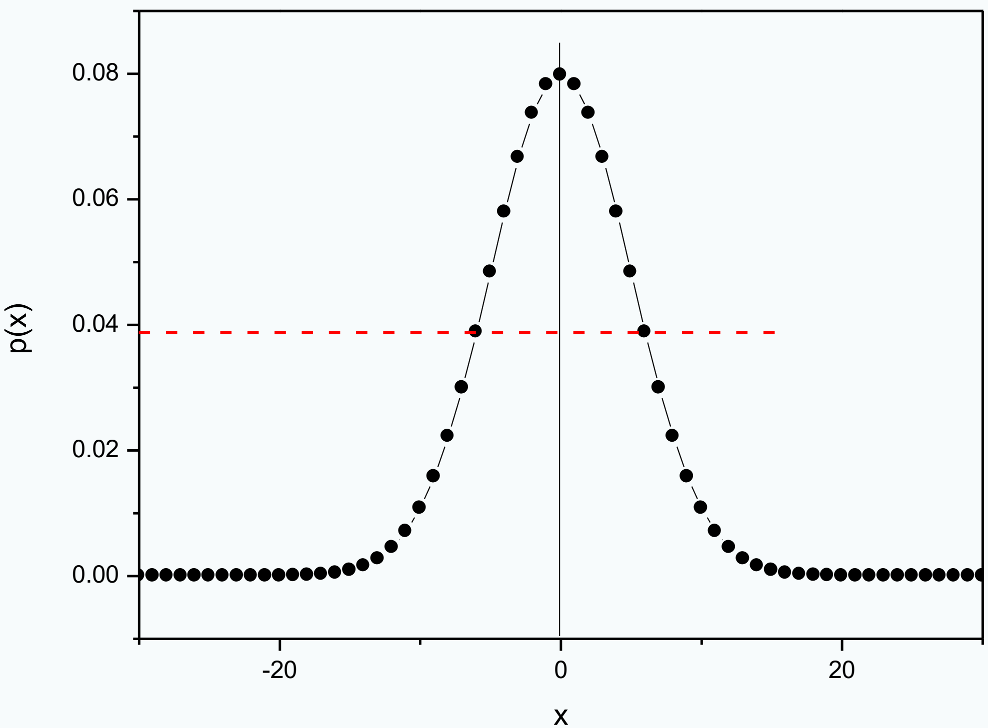
$$\left| \frac{x_i - x_r}{x_r} \right|$$ - relative error

Average value

$\langle x \rangle$ - typically denotes an ensemble averaged value

$$\langle x \rangle = \frac{1}{N}\sum_{i=1}^{N} x_i$$

With increasing number N of trials, $<x>$ will tend to x_r!



Gaussian or error function, normal distribution

$p(x)\mathrm{d}x$ – probability that a measured quantity lies between x and $x+\mathrm{d}x$

$$p(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left\{ -\frac{(x-x_r)^2}{2\sigma^2} \right\}$$

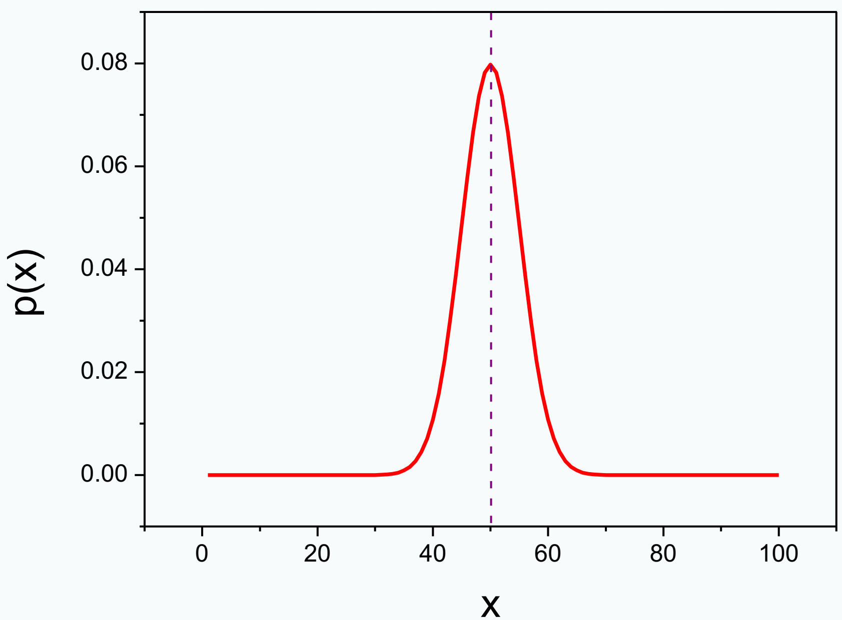
σ – standard deviation

σ^2 – variance, mean square deviation

$$\int_{-\infty}^{\infty} p(x)dx = 1$$

$$\int_{-\infty}^{\infty} xp(x)dx = x_r$$

$$\int_{-\infty}^{\infty} (x-x_r)^2 p(x)dx = \sigma^2$$



Uncertainty

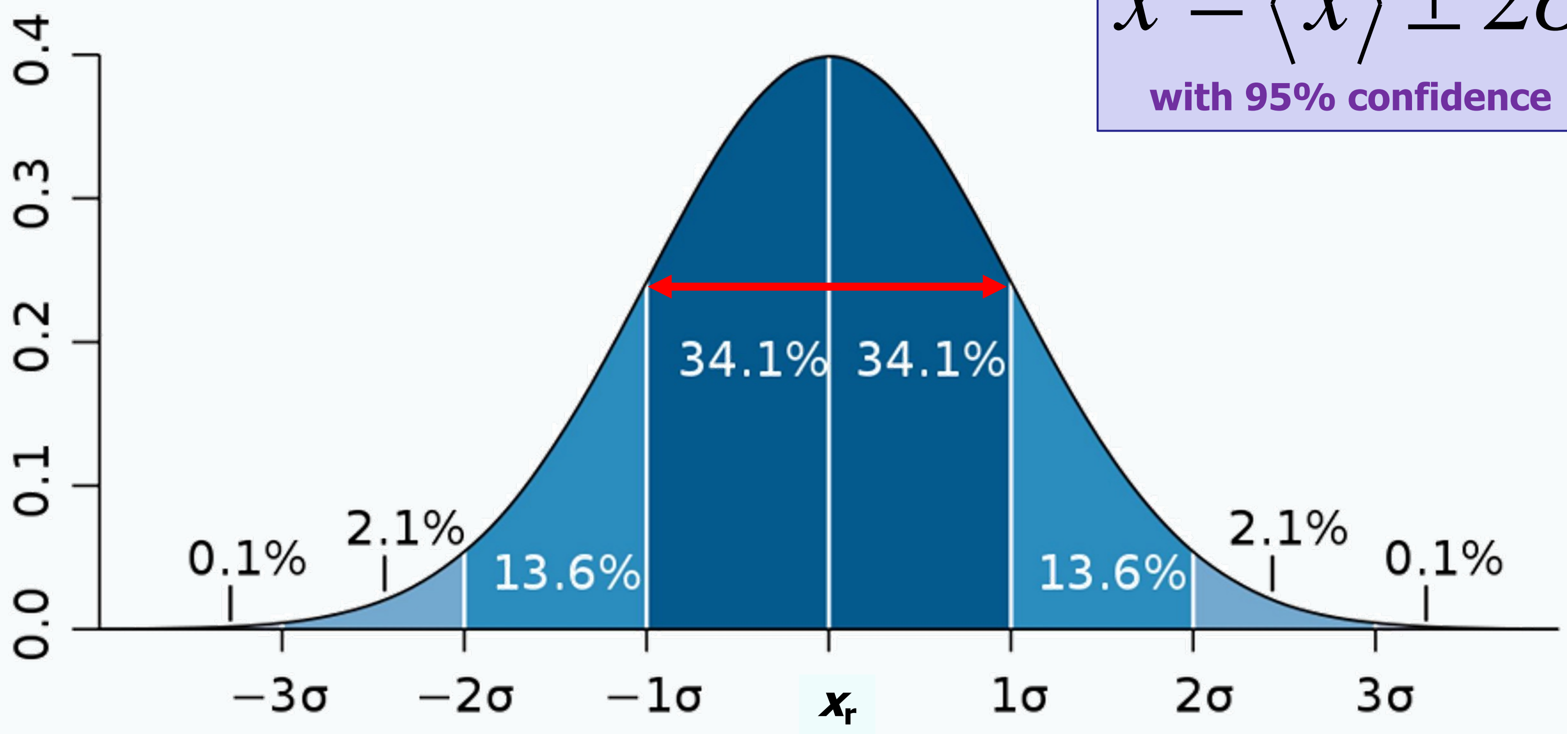
$$P(\Delta) = \int_{x_r - \Delta}^{x_r + \Delta} p(x)dx$$

$$x = \langle x \rangle \pm \sigma$$

with 68% confidence

$$x = \langle x \rangle \pm 2\sigma$$

with 95% confidence



Uncertainty of the mean

$$\langle x \rangle = \frac{1}{N}\sum_{i=1}^{N} x_i$$

Mean value

$$\sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \langle x \rangle)^2}$$

Standard deviation

$$u = \frac{\sigma}{\sqrt{N}} = \sqrt{\frac{1}{N(N-1)}\sum_{i=1}^{N}(x_i - \langle x \rangle)^2}$$

Standard deviation of the mean

To remember!

- The International System of Units (SI). It is a good custom to provide anything in the SI units.
- Always check yourself for a proper dimension.
- It might be very helpful to check the order-of-magnitude value.
- Errors are important! Do not forget to report on the uncertainty and to round the values.