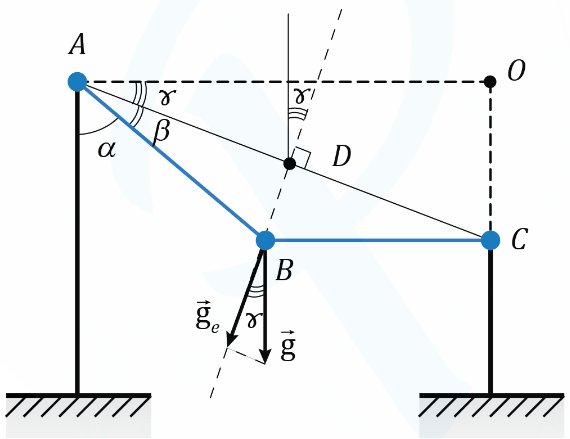
General Strategies

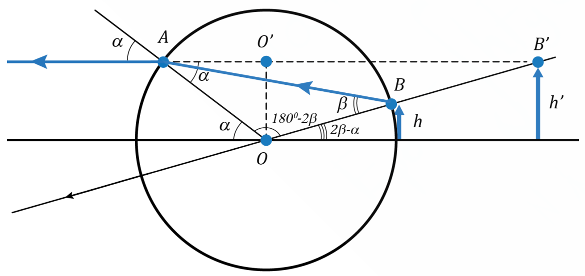
- Detailed solutions to all problems are provided in the PhysOlymp.com system, which encourages to try several approaches and think at least one full day before looking at the official solution
- With any suggestions please write at **feedback@physolymp.com**

Before jumping to solving actual problems please read through basic strategies that work for almost any questions. No need to seek for meaning of every symbol at the pictures or equations at this particular chapter, which is given only as a short overview. Detailed comments to specific problems will be provided further. Thus, every of the below discussed strategies will be repeated hundreds of times down the road at different examples For solving most of the Physics problems it is highly recommended after reading carefully the question to visualize discussed situation in a manner that will expose physical laws that can be written in mathematical form. It should not be accurate 3D sketch, but rather very simple 2D drawing with indication of key dimensions of the system, direction of forces, lines of the fields or other physical parameters that can be used further in writing equations

Draw a large picture

Always draw big scale pictures, so you will not lose any valuable information, in a dozen different notations at the picture. Below are given two examples of the such typical drawings from actual problems that will be discussed in the next chapters

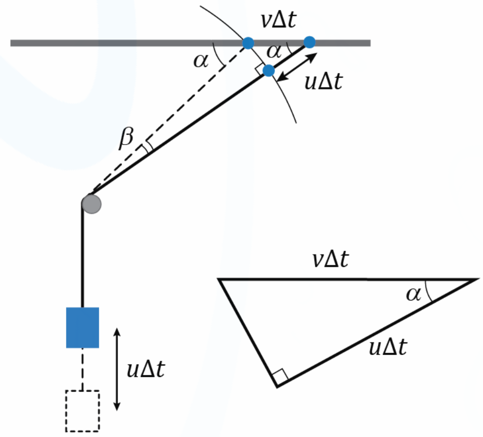




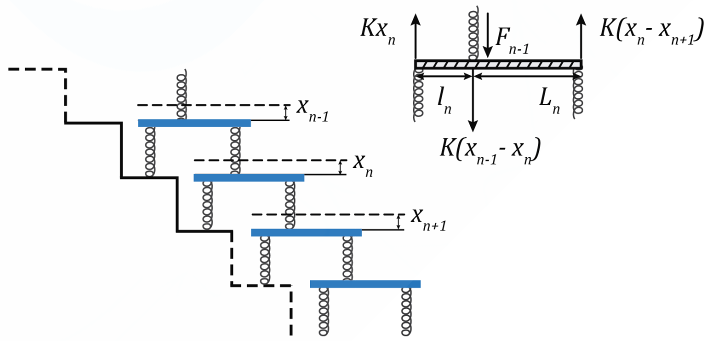
As you can see, if making sketches of the small size, it will be very challenging to discern different specific angles and writing relevant geometric relations for the problem. So, make a habit of not just drawing some picture, but drawing clear, large-size figures

Zoom in

In some particular problems, no matter how big will be schematics of the system, some part of it still will be too small. It can be encountered quite often with problems when describing infinitesimal changes in the system. For such situations try to zoom in some small part of the system, that will allow to find relation between several infinitesimal parameters. In the example shown below was considered a snapshot of the system after a very small period of time Δt. To better see all the details, enlarge portion of the right triangle was drawn besides a sketch of the whole system

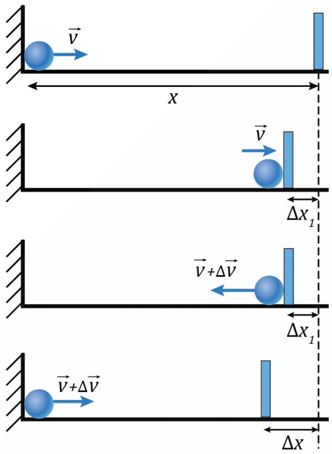


Similar strategy with drawing a larger version of the part of the system, with detailed notations to prevent the drawing of becoming too messy

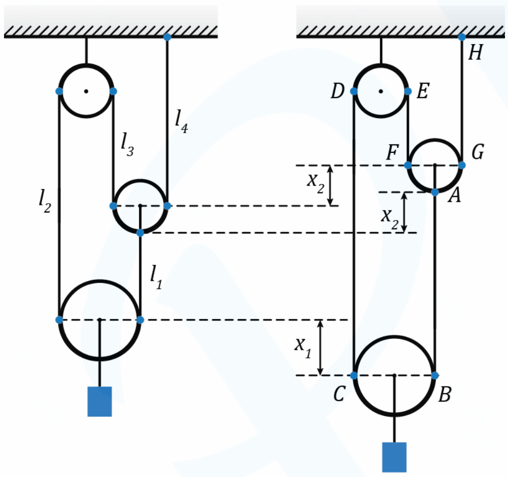


Drawing snapshots

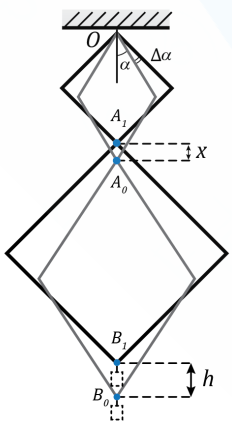
Many of the complex phenomena can be easily described in mathematical way by drawing several snapshots of the dynamic movement. For example, if a ball is bouncing between a fixed wall and moving piston, its motion can be described by observing one full cycle between the wall and piston, with changing velocities after bouncing and distance between obstacles. This type of pictures should be drawn in parallel to initial condition, to see a clear change after each step



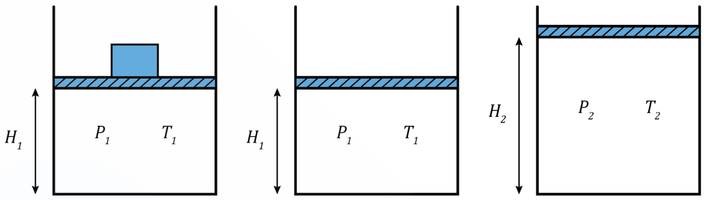
Similar parallel snapshots are recommended for Atwood machines, with multiple weights, strings and pulleys. To find relation between velocities or accelerations of several components of the system, we usually look at the change of the length of each section of the rope. This technique will be covered further with many examples and problems. For now just get familiar with useful approach of depicting snapshots of the changing system at several time intervals



One more examples of time dependant state of the system

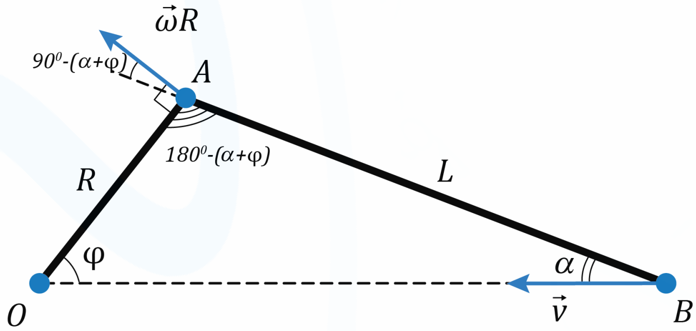


Also can be useful for visualizing given conditions, in form of pictures. Such as pressure/temperature and size of the vessel with gass during three different situations, which were described in words in the question



Avoid drawing symmetrical forms for arbitrary system

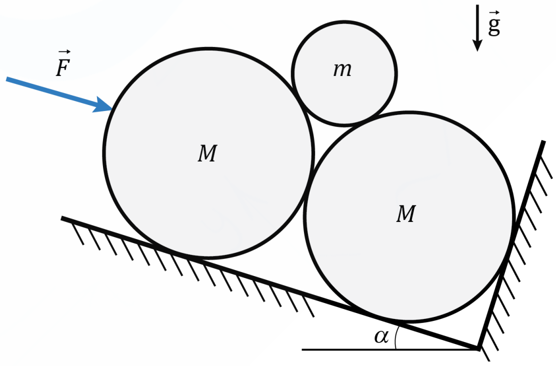
Picture is powerful. Poorly sketched drawing can lead to the wrong conclusion, distracting with a symmetry that is not actually present in the problem. Avoid drawing arbitrary triangles that will look similar to isosceles or with one of the angles that will be visually close to 45° or 90°. For the picture presented below, inexperienced student, can accidentally draw triangle ΔABC with angle $\angle A$ look as 90° and this can lead to the wrong implication between relations of the vectors



So, if when depicting an arbitrary system it looks as some symmetrical form, it is good to draw picture again. This will not take much time, but will guard against of taking a false path

Drawing complex system by separate parts

Interaction of several bodies is better to illustrate by separate components of the system. This will make figures more clear, avoiding a mess of too many notations at one drawing. Example of such approach is drawing free body diagram for the system consisting from three cylinders



Instead of denoting vectors at the actual system, with tight contact between all three bodies, more useful will be drawing imaginary situation, as all the cylinders were separated by some significant distance from each other, but applying the third Newton's law, with direction of vectors in opposite direction at the points of contact between objects

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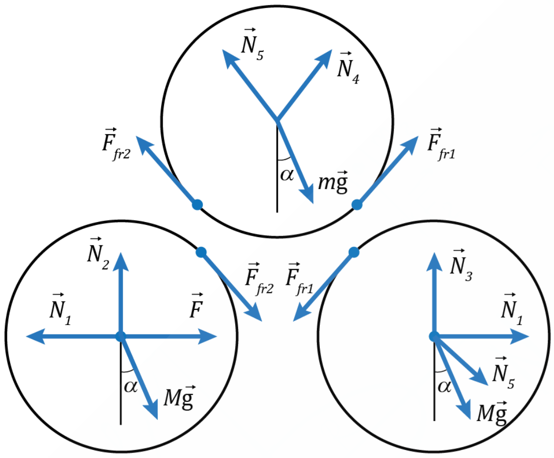
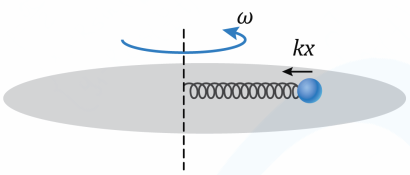
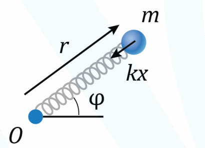
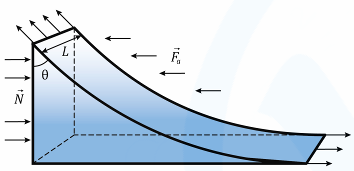


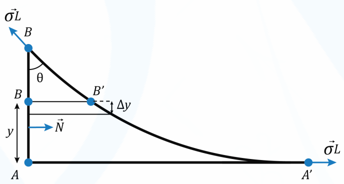
2D/3D representation

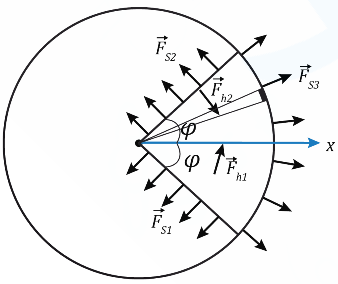
Real life systems are all occuringing in three-dimensional space (3D). However, to simplify the problem and describing physical laws, in most of the cases more appropriate will be illustrating complex 3D system as a 2D snapshot from the side or from the top. Usually, only 2D sketch is enough for getting insight about phenomena, however in some cases as shown in examples below, drawing both 3D and 2D schematics will provide a deep understanding of situation, with opening a clear path to writing mathematical relations for the system

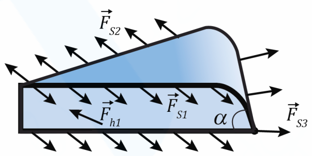












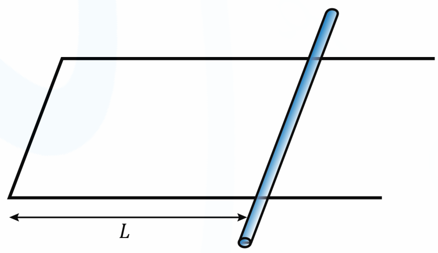
Always solve problems in symbols, no matter how simple it seems to do in numerical values. This will allow to validate all your work with checking for dimensions or special cases. In writing equations don't limit yourself with several variables given in the problem statement, on the contrary, create a lot of additional variables, which can be relevant to the problem, assume that everything is given and write down some relations, describing physical laws in mathematical way

As a prominent example of such approach, let's take a look at one of the questions, where from the problem statement seems that nothing was given to characterize it quantitatively. However, if assuming that everything is given, introducing a dozen of new variables, with writing multiple physical laws, which describe situation in form of equation, then in the end most of the new variables will be eliminated. It looks like a magic!

Don't try to understand meaning of each symbol or what laws are behind those equations, it is just an example of the general approach how to solve problems in physics. Quickly go through the example, more details explaining actual laws will be given in the chapters dedicated to magnetic field

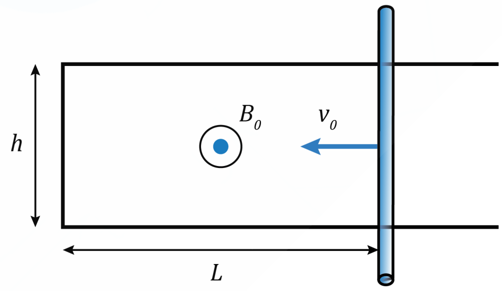
Example 1

Metallic rod with uniformly distributed properties is placed on top of the $\prod$ shaped wire, which is located in horizontal plane. Orientation of the rod is perpendicular to the parallel sections of the wire. Initial distance between the rod and bended part of the wire is L as shown at the picture below. Suddenly external magnetic field is applied in vertical direction. Find new distance between the rod and bended part of the wire S, assuming that there is no friction between rods and wire, and resistance of the rods is much larger than resistance of the wire



It seems that almost nothing is given to answer definitely for the question. Neither value of magnetic field B, nor resistivity of the rod R, nothing except initial distance between rods L. However, it is still possible to solve this problem with very limited given information

Start with drawing a large picture



Let us denote some relevant parameters of the system as

- h is distance between two parallel sections of the wire
- B_0 - external magnetic field

- v_0 - initial velocity of the rod after "switching on" magnetic field
- I - electrical current in the loop
- Φ - magnetic flux through the closed loop
- R - resistivity of the rod
- m - mass of the rod
- x - distance between the rod and bended part of the wire, when velocity of the rod is equal v

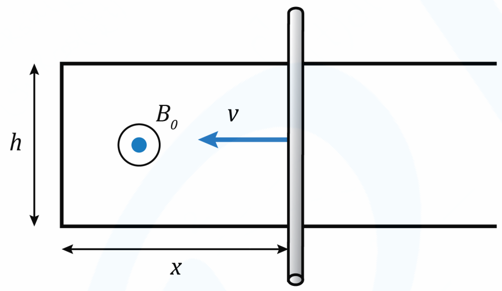
All those variables allow to describe physical phenomenon in mathematical equations:

$$IR = \left|\frac{\Delta\Phi}{\Delta t}\right| = Lh\frac{dB}{dt}$$

$$F = IBh = m\frac{dv}{dt}$$

$$Lh^2\int_0^{B_0} BdB = m\int_0^{v_0} dv$$

$$\frac{1}{2}Lh^2B_0^2 = mv_0$$



$$IR = B_0h\frac{dx}{dt}$$

$$m\frac{dv}{dt} = -|I|B_0h = -B_0^2h^2\left|\frac{dx}{dt}\right|$$

$$m\int_{v_0}^{0} dv = B_0^2h^2\int_L^S dx$$

$$mv_0 = B_0^2h^2(L-S)$$

$$\frac{1}{2}Lh^2B_0^2 = B_0^2h^2(L-S)$$

$$\boxed{S = \frac{L}{2} = 0.5\,m}$$

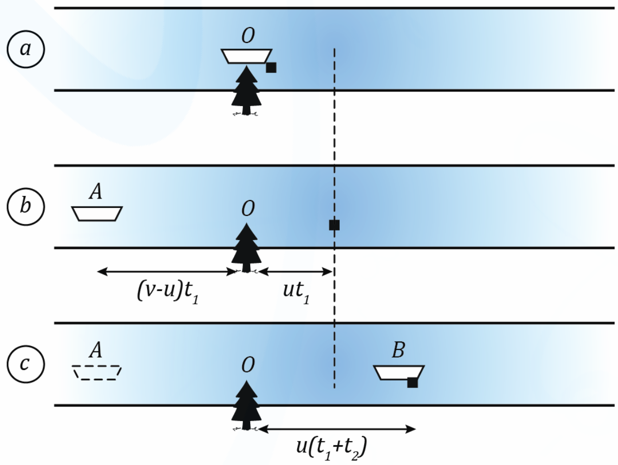
So, main point is not to limit yourself with information that is given. For any problem assume that everything is known, introduce all kinds of variab- les and write equations for relevant physical laws. Down the road, many of the variables possibly will be eliminated with the left equations containing only given information

Synthesis of both strategies with drawing large pictures/snapshots and introducing multiple variables for description of the situation is provided in following simple example and the first problem, where you will have a chance to earn the first 1.0 point for the correct answer

Example 2

A fisher initially swims in the boat upstream of the river. His life vest fell out of the boat, when passing a branchy tree. The fisher had noticed his lost item only after $5\,minutes$ from its fall and turned immediately the boat down the river. At what distance from the tree, fisher will catch his life-vest, if speed of the river is $1\,m/sec$?

This question can be easily solved at the reference frame of the life-vest, with a very short solution. However, for the purpose of providing a simple example with application of aforementioned strategies, we will solve the problem in the regular reference frame with the bank of the river. Start with drawing shapshots, assuming that all relevant variables are known



Let u is speed of the river, and v is velocity of the boat in respect to the river. Then before noticing the lost item, fisherman will move away from the tree by distance

$$OA = (v-u)t_1$$

where $t_1 = 5min$ is a known variable for time past before turning direction of the boat. If the life-vest will be caught at the point B down the river, after time t_2 from the turning moment, then total distance AB covered by the boat down the river can be expressed in two ways

$$AB = (v+u)t_2$$

$$AB = AO + OB = (v-u)t_1 + L$$

where $L = u(t_1 + t_2)$ is required distance from the tree. At the first glance there are too many variables, nevertheless we will try to eliminate some of them with hope that the rest will be canceled out. For example, if substitute variable of t_2 as

$$t_2 = \frac{L}{u} - t_1$$

into equations of the distance AB, this will result in following relation

$$AB = (v+u)\left(\frac{L}{u} - t_1\right) = (v-u)t_1 + L$$

Expanding terms of the last equation many of the components will be canceled except following simple expression

$$\boxed{L = 2ut_1}$$

Only after obtaining final answer in the symbolic form, we will use numerical values from the question

$$L = 2 \cdot 1 \cdot 5 \cdot 60 = 600m$$

where was accounted that one minute is equivalent to 60 seconds

Summarizing solution, we started with describing text of the problem in relevant pictures, assigning appropriate names to the variables. Then assuming that everything is known, we were writing several simple formulas and finally solved a system of equations by eliminating some of the unknowns. Only after getting final result in the symbolical form, numerical values were used

Now reinforce learning of all those concepts by trying to solve the next problem. Start with drawing simple pictures, understand physical essence of the problem; assign multiple variables and describe whole situation with relevant equations

Problem 1

Regular pace of the person is $v = 5km/h$. He counts $N = 60$ steps, while descending in the underground with escalator, which moves downward with a speed $u = 0.75m/s$. How many steps N_0 are visible at the escalator? (Picture provided below is for illustration purpose only)