KIT - International Department GmbH

Pre-Semester Physics - Exercises **Summer 2010**

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Extra Sheet I
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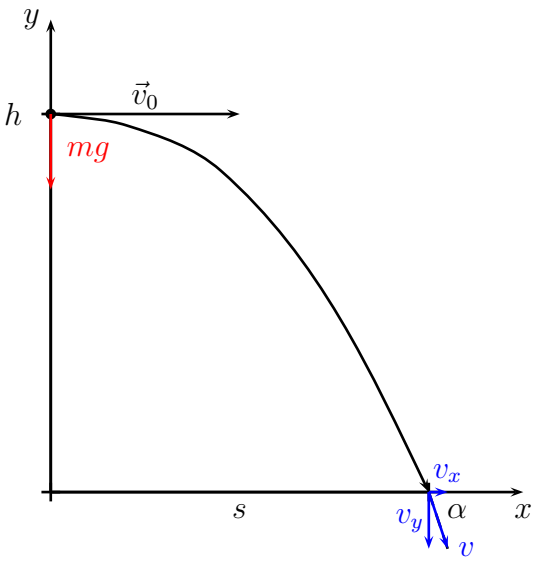
1. Exercise:



A stone $m = 1\,\text{kg}$ is thrown from a tower with height $h = 20\,\text{m}$ horizontally with velocity $v_0 = 10\,\frac{\text{m}}{\text{s}}$. Gravity is acting along the vertical with $g = 10\,\frac{\text{m}}{\text{s}^2}$.

(a) Take for example the position for $t = 0$. Draw in the diagram all forces acting on the stone.

(b) What kind of motion performs the body along the x-direction?

☒ uniform motion ☐ motion with constant acceleration ☐ circular motion

(c) What kind of motion performs the body along the y-direction?

☐ uniform motion ☒ motion with constant acceleration ☐ circular motion

(d) What are the initial velocities in x and y-direction?

$$\boxed{v_{0,x} = v_0 = 10\,\frac{\text{m}}{\text{s}}}$$

$$\boxed{v_{0,y} = 0}$$

(e) How is the distance traveled along the x-direction depending on time?

$$\boxed{x(t) = v_0 t = 10\,\tfrac{\mathrm{m}}{\mathrm{s}} \cdot t}$$

(f) How is the distance traveled along the y-direction depending on time?

$$\boxed{y(t) = -\tfrac{1}{2} g t^2 + h = -5\,\tfrac{\mathrm{m}}{\mathrm{s}^2} \cdot t^2 + 20\,\mathrm{m}}$$

(g) How is the velocity in x-direction depending on time?

$$\boxed{v_x(t) = v_0 = 10\,\tfrac{\mathrm{m}}{\mathrm{s}}}$$

(h) How is the velocity in y-direction depending on time?

$$\boxed{v_y(t) = -gt = -10\,\tfrac{\mathrm{m}}{\mathrm{s}^2} \cdot t}$$

(i) Solve the equation for $y(t)$ in order to get the time when the stone impacts with the ground.

$$\boxed{t = \sqrt{\tfrac{2h}{g}} = 2\,\mathrm{s}}$$

(j) Put this time into the formula for $x(t)$ to get the range:

$$\boxed{s = v_0 \sqrt{\tfrac{2h}{g}} = 20\,\mathrm{m}}$$

(k) Put the time of impact into the formula of $v_x(t)$ and $v_y(t)$ in order to get the component of the velocity at the time of impact.

$$\boxed{v_x(t) = 10\,\tfrac{\mathrm{m}}{\mathrm{s}}}$$

$$\boxed{v_y(t) = -20\,\tfrac{\mathrm{m}}{\mathrm{s}}}$$

(l) Calculate the absolute value of the velocity at the time of impact.

$$\boxed{v = \sqrt{v_x(t)^2 + v_y(t)^2} = 22.4\,\tfrac{\mathrm{m}}{\mathrm{s}}}$$

(m) Draw the velocity as well as its components at the time of impact in the diagram above.

(n) Determine the angle at which the stone impacts with the ground with respect to the horizontal.

$$\boxed{\alpha = \arctan\left(\tfrac{v_y}{v_x}\right) = 63^\circ}$$