University Karlruhe - International Department

Pre-Semester Physics - Solutions Summer 2009

Holger Schmidt
hschmidt@tkm.uni-karlsruhe.de

Sheet 1
19.8.2009

---

1. Exercise

It is $t = t_1 + t_2$. t_1 is the time from the cliff to the sea. Time t_2 the time from the incident to the ground. It is

$$t_1 = \sqrt{\frac{2h_1}{g}} \approx 3.16s\,.$$

The velocity right at the incidence v_1 is given by

$$v_1 = \sqrt{2gh_1} \approx 31.62\frac{m}{s}$$

The time t_2 reads

$$t_2 = \frac{h_2}{v_1} = 0.31s.$$

2. Exercise

Choose $x = 0$ and $t = 0$ the position and time where the racer and the police meet. The racer has $x_r(t) = vt$ and the police $x_p(t) = 5t^2$. For the time t we find:

$$vt = \frac{a}{2}t^2 \quad \Leftrightarrow \quad t = \frac{2v}{a} = 4\,s$$

3. Exercise

It is $t = t_1 + t_2$, where t_1 is the time the stone needs to hit the ground of the fountain and t_2 is the time of the sound needs t o reach your ear.

$$t_1 = \sqrt{\frac{2h}{g}}, \qquad t_2 = \frac{h}{v_{ac}}$$

Thus

$$t = \sqrt{\frac{2h}{g}} + \frac{h}{v_{ac}} \quad \Leftrightarrow \quad t - \frac{h}{v_{ac}} = \sqrt{\frac{2h}{g}} \quad \Leftrightarrow \quad (t - \frac{h}{v_{ac}})^2 = \frac{2h}{g}$$

This yields the required quadratic equation for h:

$$h^2 - 2v_{ac}(t + \frac{v_{ac}}{g})h + t^2 v_{ac}^2 = 0$$

Putting in the values for $v_{ac} = 340\,m/s$, $g = 10\,m/s^2$ and $t = 5s$ we obtain $h \approx 109.43m$.

4. **Exercise**

Let $v = 20\frac{m}{s}$. With $\sin 45° = \cos 45° = \frac{1}{\sqrt{2}}$ we have

$$\vec{x}(t) = \begin{pmatrix} \frac{v}{\sqrt{2}}t \\ \frac{v}{\sqrt{2}}t - \frac{g}{2}t^2 \end{pmatrix}, \qquad \vec{v}(t) = \begin{pmatrix} \frac{v}{\sqrt{2}} \\ \frac{v}{\sqrt{2}} - gt \end{pmatrix}$$

The total time the mass point is in the air is thus given by

$$\frac{v}{\sqrt{2}}t - \frac{g}{2}t^2 = 0 \quad \Leftrightarrow \quad t = \frac{\sqrt{2}v}{g} \approx 2.82\,s$$

The horizontal distance d traveled is:

$$d = \frac{v}{\sqrt{2}}t = \frac{v}{\sqrt{2}}\frac{\sqrt{2}v}{g} = \frac{v^2}{g} = 40\,m$$

The maximum hight y_{max} is reached, when the velocity in the y-direction is zero:

$$\frac{v}{\sqrt{2}} - gt = 0 \quad \Leftrightarrow \quad t = \frac{v}{\sqrt{2}g}$$

Thus y_{max} is given by

$$y_{max} = \frac{v}{\sqrt{2}}\frac{v}{\sqrt{2}g} - \frac{g}{2}(\frac{v}{\sqrt{2}g})^2 = \frac{v^2}{4g} = 10\,m$$

5. **Exercise**

It is

$$v = 45\frac{km}{h} = 45\frac{1000}{3600}\frac{m}{s} = 12.5\frac{m}{s}$$

Turning on time around the whell covers a distance of ($r = 0.35\,m$)

$$\Delta x = 2\pi r$$

Thus during a leg of $d = 200000\,m$, the wheels turned n times around with

$$n = \frac{d}{\Delta x} \approx 90991.8$$

For the angular velocity we find

$$\omega = \frac{v}{r} \approx 35.71\frac{1}{s}$$

The time needed for the leg is

$$\Delta t = \frac{d}{v} = 16000\,s \approx 4.44\,h$$

6. **Exercise**

a) It is

$$\alpha = \arcsin(\omega r/v)$$

b) We have

$$t = r/\sqrt{v^2 - r^2\omega^2}$$

c) Critical angular velocity:

$$\omega = v/r$$

d) Bimbo We have

$$t = r/v \qquad \text{and} \quad \alpha = \omega r/v$$

7. Exercise

It is

$$\dot{\vec{x}}(t) = \begin{pmatrix} e^t(\cos t - \sin t) \\ e^t(\sin t + \cos t) \end{pmatrix}$$

and thus

$$|\dot{\vec{x}}(t)| = \sqrt{2e^{2t}} = \sqrt{2}e^t$$

Therefore the path length L is given by

$$L = \sqrt{2}(e^T - 1)$$