Test 4

1.

The distance to the point source of sound increased by 2 times.
Find how many times the sound intensity has decreased.

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$$r_2 = 2 \cdot r_1$$

$$I_1 = \frac{P}{4 \cdot \pi \cdot r_1^2}$$

$$I_2 = \frac{P}{4 \cdot \pi \cdot r_2^2}$$

$$\frac{I_2}{I_1} = \frac{P \cdot 4 \cdot \pi \cdot r_1^2}{4 \cdot \pi \cdot r_2^2 \cdot P} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{r_1}{2 \cdot r_1}\right)^2 = \frac{1}{4}$$

Answer: 4

2.

Intensity of sound is I = 1 [W/m^2].
Find the sound power P [W] passing through the window of 3 m^2.

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$$I = \frac{P}{A}$$

$$P = I \cdot A = 1 \cdot 3 = 3 \text{ [W]}$$

3.

Speed of sound in ideal gas is υ_1 = 100 [m/s] at T_1 = 127 °C.
Find υ_2 at T_2 = - 173 °C.

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$$\upsilon_1 = \sqrt{\frac{\gamma \cdot R \cdot T_1}{M}}$$

$$\upsilon_2 = \sqrt{\frac{\gamma \cdot R \cdot T_2}{M}}$$

$$\frac{\upsilon_2}{\upsilon_1} = \frac{\sqrt{\frac{\gamma \cdot R \cdot T_2}{M}}}{\sqrt{\frac{\gamma \cdot R \cdot T_1}{M}}} = \sqrt{\frac{T_2}{T_1}}$$

$$\upsilon_2 = \upsilon_1 \cdot \sqrt{\frac{T_2}{T_1}} = 100 \cdot \sqrt{\frac{273-173}{273+127}} = 100 \cdot \sqrt{\frac{1}{4}} = \frac{100}{2} = 50 \text{ [m/s]}$$

4.

Intensity of sound [W/m^2] is $I = 100 \cdot I_0$.
Find the sound loudness β [dB].

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$$\beta \text{ [dB]} = 10 \cdot \log_{10}\left(\frac{I}{I_0}\right) = 10 \cdot \log_{10}\left(\frac{100 \cdot I_0}{I_0}\right) = 10 \cdot \log_{10} 10^2 = 10 \cdot 2 \cdot \log_{10} 10 = 20 \text{ [dB]}$$

5.
The car creates a sound with frequency f_s = 1 kHz and moves to person at speed υ_s = 360 [km/h].
Find the frequency of sound that a person hears f [Hz].
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υ_s= 360 [km/h] = $\frac{360\cdot1000\ [m]}{60\cdot60\ [s]}$ = 100 [m/s]
υ= 343 [m/s]
$f = f_s \cdot \left(\frac{\upsilon}{\upsilon-\upsilon_s}\right)$ = 1000$\cdot\left(\frac{343}{343-100}\right)$ = 1412 [Hz]

6.
The speed of light in material is $\upsilon = 1.5\cdot10^8$ [m/s].
Find the refractive index of material n.
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$c = 3\cdot10^8$ [m/s] - the speed of light in vacuum.
$n = \frac{c}{\upsilon} = \frac{3\cdot10^8}{1.5\cdot10^8} = 2$

7.
The distance from object to thin lens is o = 12 [cm].
The distance from thin lens to image is i = 6 [cm].
Find the focal length f [cm].
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$\frac{1}{o}+\frac{1}{i}=\frac{1}{f}$
$\frac{1}{12}+\frac{1}{6}=\frac{1}{f}$
$\frac{3}{12}=\frac{1}{f}$
$f = \frac{12}{3}$ = 4 [cm]

8.
The focal length of thin lens is f = 10 [cm]
Find the lens power P [diopters].
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f = 10 [cm] = 0.1 [m]
$P = \frac{1}{f} = \frac{1}{0.1}$ = 10 [diopters]

9.
Light incident normally from a medium 1 (refractive index n_1 = 2.5) upon a medium 2 (refractive index n_2 = 1.5).
Find reflectivity R [%].

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$R = \left(\frac{n_2 - n_1}{n_2 + n_1}\right)^2 \cdot 100 = \left(\frac{1.5 - 2.5}{1.5 + 2.5}\right)^2 \cdot 100 = 6.25$ [%]

10.
The film has thickness d = 100 nm and refractive index n = 1.5.
Light (λ = 600 nm) incident normally upon this film.
Can we see the reflection of this light?
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Normally: β = 0°, cos(β) = 1
maximum reflection: $2 \cdot n \cdot d \cdot \cos(\beta) = (m - 0.5) \cdot \lambda$
$2 \cdot 1.5 \cdot 100 \cdot 1 = (m - 0.5) \cdot 600$
m = 1
Answer: yes

11.
You pass laser light λ = 600 nm through a narrow slit and observe the diffraction pattern on a screen D = 6 [m] away.
The distance on the screen between centers of first minima outside the central bright fringe is 25 mm.
How wide is the slit a [m]?
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First minima means m = 1.
$\lambda = 600$ nm $= 600 \cdot 10^{-9}$ [m]
$y = 0.5 \cdot 25 \cdot 10^{-3}$ [m]

$a = \frac{m \cdot \lambda \cdot D}{y} = \frac{1 \cdot 600 \cdot 10^{-9} \cdot 6}{0.5 \cdot 25 \cdot 10^{-3}} = 2.88 \cdot 10^{-4}$ [m]

12.
A gamma-ray photon has energy of $E = 2.209 \cdot 10^{-13}$ [J].
Find the wavelength λ [m] of this electromagnetic radiation.
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$h = 6.626 \cdot 10^{-34}$ [J·s]
$c = 3 \cdot 10^{8}$ [m/s]

$E = h \cdot f = \frac{h \cdot c}{\lambda}$
$\lambda = \frac{h \cdot c}{E} = \frac{6.626 \cdot 10^{-34} \cdot 3 \cdot 10^{8}}{2.209 \cdot 10^{-13}} = 9 \cdot 10^{-13}$ [m]