EXAM PREPARATION: OPTICS, PRESSURE

Theory: Answer the questions and explain the concepts by heart

a) Vector/scalar
b) Properties of matter: What is matter composed of? What are the properties of the building blocks of matter?
c) Quote three states of matter
d) Describe the three states of matter on the molecular level. Pay attention to the following:
   - Do the atoms and molecules have fixed positions?
   - What are the attractive forces between atoms/molecules like?
   - Are the atoms/molecules close together or far apart?
e) What is *Brownian motion*?
f) Why do most objects expand when they warm up?
g) Are gases compressible? Give reasons for your answer.
h) Are liquids compressible? Give reasons for your answer.
i) Pressure
j) Pascal's principle
k) What is the cause of pressure in a liquid?
l) What is a good rule of thumb for water pressure? (in terms of quantity)
m) What is a good rule of thumb for atmospheric pressure? (in terms of quantity)
n) What is the approximate value of atmospheric pressure at the Earth's surface?
o) Vacuum
p) Explain how a mercury barometer works (using a given picture)
q) Converging/diverging lens
r) Focal length
s) Refractive power
t) Explain how the magnified image is formed by a microscope
u) Explain how the magnified image is formed by a refracting telescope
v) Sketch an eye and label the *retina*, *cornea*, *lens* and *pupil*
w) What is the cause of nearsightedness? What kind of lens is required to correct it?
x) What is the cause of farsightedness? What kind of lens is required to correct it?

Skills:

- Transform equations, insert numbers with units into the equation, calculate results correctly
- Round your results to the correct number of significant digits and write your answer with a power of ten in the normalized scientific format
- Draw and read scientific graphs
- Convert the unit *Pascal* to *bar* and vice versa
- Convert units for area and volume
- represent vectors graphically by drawing them as arrows and solve problems by using this method
- construct image formation by plane mirrors
- construct image formation by a pinhole camera
- Know the rules for ray tracing for thin lenses
- Construct the formation of images by thin lenses using the technique of ray tracing

Formulae: A formula sheet will be handed out. Please find the formula sheet on ga.perihel.ch.

Physical quantities: Know these physical quantities by heart (symbol and unit)

	symbol	unit		symbol	unit
time			distance, displacement		
velocity			acceleration		
acceleration of free fall			mass		
work			force		
area			volume		
density			pressure		
index of refraction			speed of light		
magnification			focal length		
image height			object height		
image distance			object distance		
refractive power					

Exercises:

An algebraic solution and all values used in calculations are required to get the full mark.

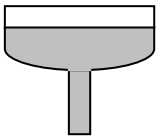
All of the work sheets and assignment sheets A29 – A34

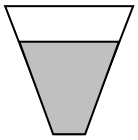
Additional problems

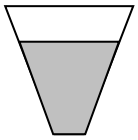
1. Complete the following sentences:
a) The …… movement of the atoms and molecules of an object, the colder is the object.
b) If the movement of an object's particles becomes less intense, the particles need ……. room for moving about and the object ……. .

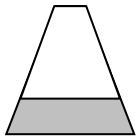
2. Convert
a) 20.7 m^3 to dm^3, cm^3 and mm^3
b) 4.30 mm^2 to cm^2 and m^2
c) 8.351 m^3 to dm^3 and mm^3
d) 5 cm^3 to m^3
e) 0.0467 m^2 to cm^2

3. These vases are filled with a liquid and open at the top. Rate them according to the pressure exerted at the bottom of the vase. Give reasons for your answer.

a) 
water

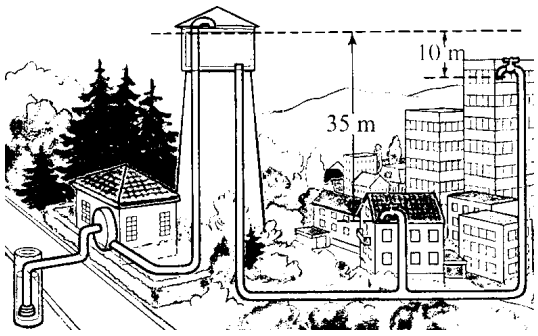
b) 
alcohol

c) 
water

d) 
alcohol

4. Using the „rule of thumb“ for water pressure: At what depth below the water's surface is the total pressure three times the value of the pressure above the surface?

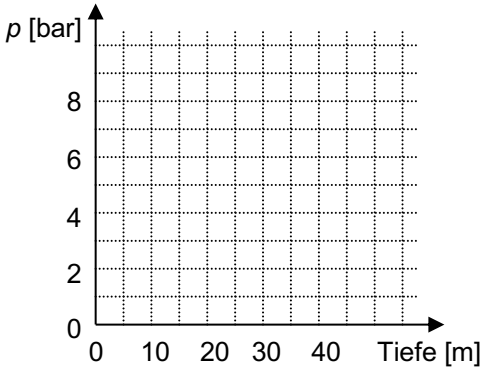
5.



a) What is the water pressure at the faucet of the small house?
b) What ist the water pressure at the faucet of the high rise building?
c) How far below the reservoir tank is the faucet of a house with pressure 4.5 bar?

6. In a village on mars the water reservoir is 270.0 m above mars' ground.
a) What is the pressure at the faucet of a house at 180.0 m above ground?
b) In another house the water pressure at the faucet is 1.6 bar. What is the height above ground of the second house?

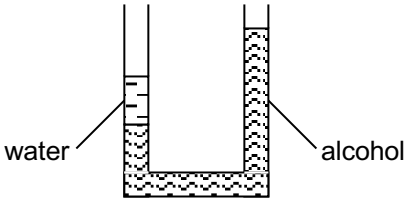
7. Draw the graph showing how pressure beneath the surface of water depends on the depth. Use the rule of thumb for determining the water pressure.
a) only fluid pressure (no atmospheric pressure)
b) total pressure (including atmospheric pressure)
c) At what depth is the total pressure four times the value of the total pressure at a depth of 20 m?



8. A vase is filled to 80.0 cm with alcohol. Atmospheric pressure is 987 mbar.
What is the total pressure at the bottom of the vase?

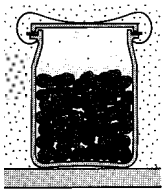
9. The window of an aquarium is 5.00 m wide and 1.60 m high. The water's surface is 20.0 cm above the upper rim of the window
What is the force exerted on the window by the water?

10. Here the columns of the liquids are at different heights. The column of water is 8.00 cm high.
a) Why?
b) What is the difference in height between the two surfaces?



11. Clumsinella steps on your foot with one of her high heels (A = 0.005420 dm^2) ... that hurts!!!! The pressure is 0.1180800 · 10^3 bar!!! Clumsinella's weight is to be calculated.
a) Place a dot above the digits which are significant. How many significant digits do the values which are needed in the calculation have? How many significant figures does your final answer require?
b) Calculate Clumsinella's weight (in N) and round your result to the correct number of significant figures.
c) Write your result in the normalized scientific notation (with a power of ten).

12.



If you're making jam, you fill the boiling product into the jar. The water vapor in the glass displaces air, and when it cools down hardly any molecules remain between the jam and the lid.
The inside pressure is 20.0 mbar, while atmospheric pressure is 980.0 mbar. Calculate the force exerted on the lid (A = 57.0 cm^2).

13. Using a hydraulic lifter, an object of weight F_2 = 60.0 kN shall be lifted over a height of s_2 = 2.00 m. The area of the (smaller) pump piston is A_1 = 5.0 cm^2, and area of the (larger) load piston is A_2 = 400.0 cm^2.
a) What is the pressure in the liquid in bar?
b) Calculate the force needed at the pump piston.
c) What is the total displacement of the pump piston?

14. A Christmas tree is located at 0.022270 km from the pupil of an eye. The eyeball's length is 0.0232600 m and the image height on the retina is 0.940 mm. The tree's height is to be calculated.
a) Place a dot above the digits which are significant. How many significant digits do the given values have? How many significant figures does your final answer require?
b) Calculate the tree's height (in mm) and round your result to the correct number of significant figures.
c) Write your result in the normalized scientific notation (with a power of ten).

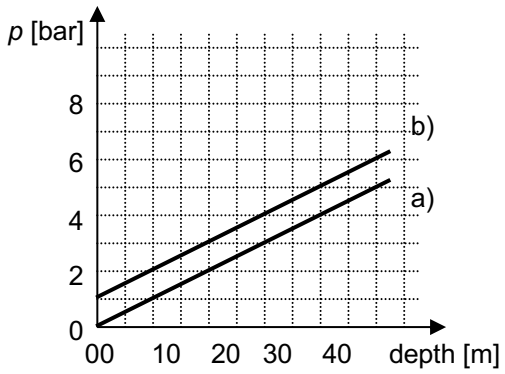
15. Calculate the power of a lens of focal length –20.0 cm.

16. Calculate the focal legth of a lens of power + 2.50 D.

17. A woman who is 1.66 m tall is standing at a distance of 6.47 m from the lens of a camera (P = 18.2 D).
What is the image height?

Solutions:

1. a) slower b) less, contracts
2. a) 20.7 m^3 = 20'700 dm^3 = 20'700'000 cm^3 = 20'700'000'000 mm^3
   b) 4.30 mm^2 = 0.0430 cm^2 = 0.00000430 m^2
   c) 8.351 m^3 = 8'351 dm^3 = 8'351'000'000 mm^3
   d) 5 cm^3 und 0.000'005 m^3
   e) 0.0467 m^2 = 467 cm^2
3. a) > c) > b) > d)
4. 20 m underneath the water's surface the fluid pressure is 2 bar and atmospheric pressure is 1 bar. Total pressure is 3 bar, which is three times the value of the pressure above the water surface.
5. a) $p = \rho_{water} \cdot g \cdot h = 998 \frac{kg}{m^3} \cdot 9.81 \frac{m}{s^2} \cdot 35\ m = 342'663\ Pa = \underline{3.4\ bar}$
   b) $p = \rho_{water} \cdot g \cdot h = 998 \frac{kg}{m^3} \cdot 9.81 \frac{m}{s^2} \cdot 10\ m = 97'903\ Pa = \underline{0.98\ bar}$
   c) $h = \frac{p}{\rho \cdot g} = \frac{4.5 \cdot 10^5\ Pa}{998 \frac{kg}{m^3} \cdot 9.81 \frac{m}{s^2}} = \underline{46\ m}$
6. a) $p = \rho_{water} \cdot g_{mars} \cdot h = 998 \frac{kg}{m^3} \cdot 3.73 \frac{m}{s^2} \cdot 90.0\ m = 335'029\ Pa = \underline{3.35\ bar}$
   b) $h = \frac{p}{\rho \cdot g} = \frac{1.6 \cdot 10^5\ Pa}{998 \frac{kg}{m^3} \cdot 3.73 \frac{m}{s^2}} = 43$ m below the water tank, that is
   270.0 m – 43 m = <u>227 m above ground</u>

7. 

c) 20 m below the surface pressure is 3 bar
110 m below the surface pressure is 12 bar

8. $p_{total} = p_{atmospheric} + \rho_{alcohol} \cdot g \cdot h = 9.87 \cdot 10^4 \text{ Pa} + 789 \frac{\text{kg}}{\text{m}^3} \cdot 9.81 \frac{\text{m}}{\text{s}^2} \cdot 0.800 \text{ m} = \underline{1.05 \text{ bar}}$

9. Fluid pressure needs to be calculated at the center of the window:
$h = 0.80 \text{ m} + 0.200 \text{ m} = 1.00 \text{ m}$

$F = p_{fluid} \cdot A = \rho_{water} \cdot g \cdot h \cdot A = 998 \frac{\text{kg}}{\text{m}^3} \cdot 9.81 \frac{\text{m}}{\text{s}^2} \cdot 1.00 \text{ m} \cdot 5.00 \text{ m} \cdot 1.60 \text{ m} = \underline{78.3 \text{ kN}}$

10. a) At the level where water and alcohol meet on the left side, pressure is the same on both sides. The lower density of alcohol needs a higher column of liquid in order to produce the same amount of pressure as in water on the right side.

b) $p_{left} = p_{right}$ $p_{left} = \rho_{water} \cdot g \cdot h_{left}$ $p_{right} = \rho_{alcohol} \cdot g \cdot h_{right}$

$\rho_{water} \cdot g \cdot h_{left} = \rho_{alcohol} \cdot g \cdot h_{right}$

$h_{right} = \frac{\rho_{water} \cdot h_{left}}{\rho_{alcohol}} = \frac{998 \frac{\text{kg}}{\text{m}^3} \cdot 0.080 \text{ m}}{789 \frac{\text{kg}}{\text{m}^3}} = 0.100 \text{ m} = 10.0 \text{ cm}$ 10.0 cm - 8.0 cm = $\underline{2.0 \text{ cm}}$

11. a) $A = 0.005\dot{4}2\dot{0} \text{ dm}^2$: 4 significant figures, $p = 0.\dot{1}1\dot{8}0\dot{8}0\dot{0} \cdot 10^3$ bar: 7 significant figures, result: 4 digits

b) $F = p \cdot A = 0.1180800 \cdot 10^8 \text{ Pa} \cdot 0.005420 \cdot 10^{-2} \text{ m}^2 = 639.9936 \text{ N} = \underline{640.0 \text{ N}}$

c) $\underline{6.400 \cdot 10^2 \text{ N}}$

12. $p = p_{outside} - p_{inside} = \frac{F}{A}$ $p = (980.0 - 20.0) \text{ mbar} = 9.60 \cdot 10^4 \text{ Pa}$

$F = p \cdot A = 9.60 \cdot 10^4 \text{ Pa} \cdot 57.0 \cdot 10^{-4} \text{ m}^2 = \underline{547 \text{ N}}$

13. a) $p = \frac{F_2}{A_2} = \frac{60.0 \cdot 10^3 \text{ N}}{0.04000 \text{ m}^2} = 1.50 \cdot 10^6 \text{ Pa} = \underline{15.0 \text{ bar}}$

b) $F_1 = p \cdot A_1 = 1.50 \cdot 10^6 \text{ Pa} \cdot 0.00050 \text{ m}^2 = \underline{0.75 \text{ kN}}$

c) $s_1 = \frac{F_2 \cdot s_2}{F_1} = \frac{60.0 \cdot 10^3 \text{ N} \cdot 2.00 \text{ m}}{0.75 \cdot 10^3 \text{ N}} = \underline{160 \text{ m}}$

14. a) $d_o = 0.0\dot{2}\dot{2}\dot{2}\dot{7}\dot{0}$ km (5 significant figures); $d_i = 0.0\dot{2}3\dot{2}\dot{6}\dot{0}\dot{0}$ m (6 significant figures); $h_i = 0.0\dot{9}4\dot{0}$ mm (3 significant figures); result: 3 significant figures

b) $h_o = \frac{h_i \cdot d_o}{d_i} = \frac{0.000940 \text{ m} \cdot 22.27 \text{ m}}{0.0232600 \text{ m}} = 0.89999 \text{ m} = 0.900 \text{ m} = \underline{900 \text{ mm}}$

c) $h_o = \underline{9.00 \cdot 10^2 \text{ mm}}$

15. $P = \frac{1}{f} = \frac{1}{-0.200 \text{ m}} = \underline{-5.00 \text{ D}}$

16. $f = = \frac{1}{P} = \frac{1}{2.50 \text{ D}} = \underline{0.400 \text{ m}} = \underline{40.0 \text{ cm}}$

17. $f = \frac{1}{P} = \frac{1}{18.2 \text{ D}} = 0.0549 \text{ m} = 55 \text{ mm}$

$d_i = \frac{d_o \cdot f}{d_o - f} = \frac{647 \text{ cm} \cdot 5.49 \text{ cm}}{647 \text{ cm} - 5.49 \text{ cm}} = 5.54 \text{ cm}$

$h_i = \frac{d_i \cdot h_o}{d_o} = \frac{5.54 \text{ cm} \cdot 166 \text{ cm}}{647 \text{ cm}} = \underline{1.42 \text{ cm}}$