BMEGEÁTBG04 1st MID-TERM	**EVALUATION**	max.50 points
Air Pollution, Waste Water and Solid Wastes Management **1st part: Particle removal from gases** Lecturer: Dr. Jenő M. Suda **24 Sept 2024, 45 min, room: D316A**	RESULT=	% (min. 30% is a must)

NAME (USE CAPITALs!): **NEPTUN code:** **SEAT Nr.:**

....X.....

IMPORTANT RULES: Use only a pen. Take care of your handwriting. Avoid being misread. Use your own wording in your answers. Note that all calculated parameters must have a unit.

Undersigned, I declare with my own signature that I have read and understood the rules.

Signature: .....**SOLUTION**.....

PROBLEM DEFINITION

A company produces plastic LEGO elements. The volume of the large production hall is $V=50000m^3$. Assume that the air ($\rho_{air}=1,2\ kg/m^3$; $\mu_{air}=2\cdot10^{-5}\ kg\cdot m^{-1}\cdot s^{-1}$) in the production hall is at rest. Due to the technology, monodispersed solid ($\rho_p=940kg/m^3$) plastic particles having $d_{p,ae}=1,5\mu m$ are continuously produced and dispersed homogeneously in the air of the production hall. It is known that the average relative distance of the particles is 2000. The production hall is equipped with an efficient particle separator (baghouse filter) that's penetration value is 10^{-4} (=0,01%). The particle separator is set to 24h continuous operation at a volumetric air flow rate of 36000 m^3/h.

QUESTIONS (each max.10 points)

QUESTION-1) Explain what "aerodynamic equivalent diameter" means.

QUESTION-2) Can we call this mixture of air+particles an "aerosol"? (yes/no) Explain your answer.

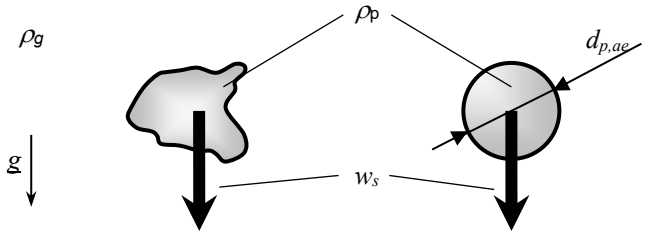
QUESTION-3) Calculate the settling velocity and the Stokes' drag coefficient during the settling process of the particles. Neglect buoyancy. Use g=10 N/kg.

QUESTION-4) Calculate the average distance between two neighbouring particles. How many particles are present in $1cm^3$ volume of this mixture?

QUESTION-5) Calculate the overall efficiency of the filtration process.

QUESTION-1) Explain what "aerodynamic equivalent diameter" means.

SOLUTION: The aerodynamic equivalent diameter is the diameter of a sphere having the same settling velocity as the real particle in the same gravity field, and also the same (still) ambient air density and same particle density is a must. (Drawing helps.)



QUESTION-2) Can we call this mixture of air+particles an "aerosol"? (yes/no) Explain your answer.

SOLUTION: yes. In the explanation, it is necessary to clarify that the aerosol is a quasi-stable mixture of gas and solid or liquid dispersed particulate phase with a diameter range between 0,01 μm and 50 μm. Here, the air of the production hall is the primary gas phase, and plastic solid particles are the secondary phase that is dispersed homogeneously in the air. The 1,5 micron-sized particles also fit the aerosol's size range.

QUESTION-3) Calculate the settling velocity and the Stokes' drag coefficient during the settling process of the particles. Neglect buoyancy. Use g=10 N/kg.

SOLUTION:

$$The\ settling\ velocity\ if\ \ buoyancy\ is\ neglected\colon\ w_s \cong \frac{\rho_p d_p^2 g}{18\mu} = 5{,}88 \cdot 10^{-5} m/s$$

$$Re_p = \frac{w_s \cdot d_p}{\nu} = \frac{w_s \cdot d_p \cdot \rho_{air}}{\mu} = 5{,}29 \cdot 10^{-6}$$

$$c_d = \frac{24}{Re_p} = 4{,}54 \cdot 10^{6}$$

QUESTION-4) Calculate the average distance between two neighbouring particles. How many particles are present in 1cm^3 volume of this mixture?

SOLUTION:

$$we\ know\ that\ \frac{a}{d_p} = 2000$$

$$a = 2000 \cdot d_p = 0{,}003m = 3mm$$

$$N = \frac{1cm^3}{a^3} = \frac{1000mm^3}{27mm^3} \cong 37$$

QUESTION-5) Calculate the overall efficiency of the filtration process.

SOLUTION:

$$1 = E + P$$

$$P = 0{,}0001 = 0{,}01\%$$

$$E = 1 - P = 1 - 0{,}0001 = 0{,}9999 = 99{,}99\%$$