Question 1 Solution:

1) For a spherical particle:

$$S = \frac{surface\,area}{volume} = \frac{4\pi r^2}{\frac{4}{3}\pi r^3} = \frac{3}{r} = \frac{3}{\frac{1}{2}d} = \frac{6}{d}\ [m^{-1}]$$

2)

$$d_1 = 50\mu m = 50 \times 10^{-6}\,m \quad \rightarrow \quad S_1 = \frac{6}{50 \times 10^{-6}} = 1.20 \times 10^5\,m^{-1}$$

$$d_2 = 100\mu m = 100 \times 10^{-6}\,m \quad \rightarrow \quad S_2 = \frac{6}{100 \times 10^{-6}} = 6.00 \times 10^4\,m^{-1}$$

3) $\epsilon = 0.39$ is the asymptotic voidage for spherical pellets as determined by Benyahia & O'Neill [http://faculty.qu.edu.qa/farid/My%20preprints/enhanced_voidage_correlations_2005.pdf]

4) $\rho = 2500\,\frac{kg}{m^3}$; $k_1 = 4.17$

$$\alpha_1 = \frac{k_1(1-\epsilon)\left(S_{o,1}^2\right)}{\epsilon^3\rho_p} = \frac{(4.17)(1-0.39)(1.20 \times 10^5)^2}{(0.39^3)(2500)} = 2.47 \times 10^8\,\frac{m}{kg}$$

$$\alpha_2 = \frac{k_2(1-\epsilon)\left(S_{o,2}^2\right)}{\epsilon^3\rho_p} = \frac{(4.17)(1-0.39)(6.00 \times 10^4)^2}{(0.39^3)(2500)} = 6.17 \times 10^7\,\frac{m}{kg}$$

Question 2 Solution

1. The assumption to use t/V vs. V plots is that the filtration is performed at constant pressure drop.

2. Precoat: In a vacuum rotary-drum, the drum neck is precoated with a medium of a known permeability and particle size to retain contaminants, producing a clear filtrate. In a solid-liquid plate-and-frame filter press, the plate is precoated to ease cake discharge and enhance filtration through forming a barrier that avoids contaminants from blinding the cloth filter, which provides a clear filtrate after the filtration cycle. (Source: www.solidliquid-separation.com/vacuumfilters/precoat.htm)

Filter aids: A finely divided material added to the feed which helps control flow and solid removal by forming a porous layer on the septum (screen or cloth) and becoming the filter medium that traps the solids and prevents them from blinding the septum.
(Source:www.generalfiltration.com/assets/uploads/filter-aid-filtration.pdf)

Question 3 Solution

The dual cyclone configuration at our sister site helps to achieve pollutant reduction by the following:

- Each cyclone separates the feed stream based on density difference. Large, denser particles travel downwards along the cyclone wall and exit the bottom as the underflow. The gas (normally air) along with fine entrained particles then travel upward as the overflow.
- Cut size becomes smaller with more units in series
- The recycle (dashed line) dilutes the feed, which reduces solid loading effect to the first cyclone and improves efficiency of system

As such, the stream discharge from cyclone 2 would have far fewer pollutant particles than our plant discharge (which has no cyclones)

Question 6 Solution

1. A venturi scrubber consists of a converging section, a throat (the narrowest part of the venturi tube) and a diffuser. The dust/gas mix flows through the venturi tube and reaches top speed in the throat section. Thereafter, the mixture passes into the diffuser where the speed drops again. Liquid is added to the gas flow either in the throat section or prior to it. Intensive mixing takes place between the gas and the liquid in the throat section of the venture tube. Due to the high speed realised by the gas and liquid, water is released in fine water droplets. (Source: http://www.emis.vito.be/techniekfiche/venturi-scrubber?language=en)

3. When compared to cyclones, venturi scrubbers have greater collection efficiency, and are able to process and capture finer particulates.

4. When compared to cyclones, venturi scrubbers are typically less reliable, and have a greater cost (e.g.: due to post-water treatment).
(Source:http://www.plastep.eu/fileadmin/dateien/Events/2011/110725_Summer_School/Vasarevicius_Air_Cleaning_PlasTEP__2_.pdf)

4M3 Assignment 3, Q4: October 2013

Define: aim: find $\alpha = \alpha_0 (-\Delta P)^f$

(α_0 unknown, f unknown)

known: $-\Delta P$ for each test

$C_s = 25$ dry solids / m^3 filtrate

$\mu = 9.2 \times 10^{-4}$ Pa.s

$A = 0.08 \ m^2$

Explore: straightforward application of filtration equations

Plan:

1. Plot t/V vs t for each test at known ΔP
2. Find slope and intercept
3. Relate this to R_m and α for each test
4. Plot α_i vs $-\Delta P_i$ for $i = 1,2,3$ and find "α_0" from "f" from log-log plot

From test 1 at $-\Delta P = 36$ kPa

slope $= 39.5 \ s/L^2$

intercept $= 58.5 \ s/L$

$$K_p = \text{slope} \times 2 \times 1000^2 \frac{L^2}{(m^3)^2} = 7.91 \times 10^7 \frac{s}{m^6}$$

$$\alpha = \frac{K_p A^2 (-\Delta P)}{\mu C_s} = 7.91$$

$$\alpha = \frac{(7.91 \times 10^7)(0.08)^2 (36000)}{(9.2 \times 10^{-4})(25)} = 7.92 \times 10^{11} \ m/kg$$

$R_m = 1.83 \times 10^{11} \ 1/m$

Test 2

	all points	omit "t = 2.5"
34.3 = slope	= ~~35.69~~ s/L²	29.8 s/L²
39.39 = intercept	= ~~36.3~~ s/L	~~42.09~~ s/L
R_m	= 1.23 × 10¹¹ 1/m	R_m = 1.32 × 10¹¹
α	= 6.87 × 10¹¹ m/kg	α = 5.97 × 10¹¹ m/kg
R_c	= 4.3 × 10¹¹ 1/m	R_c = 3.73 × 10¹¹ 1/m

not a big deal if point is retained!!

Test 2

	All points	omit "t = 2.5"
slope	= 34.3 s/L²	29.8 s/L²
intercept	= 39.39 s/L	42.1 s/L
R_m	= 4.38×10^{11} 1/m	4.69×10^{11}
α	= 2.44×10^{12} m/kg	2.12×12^{12}
R_c	= 1.53×10^{12} 1/m	1.33×10^{12}

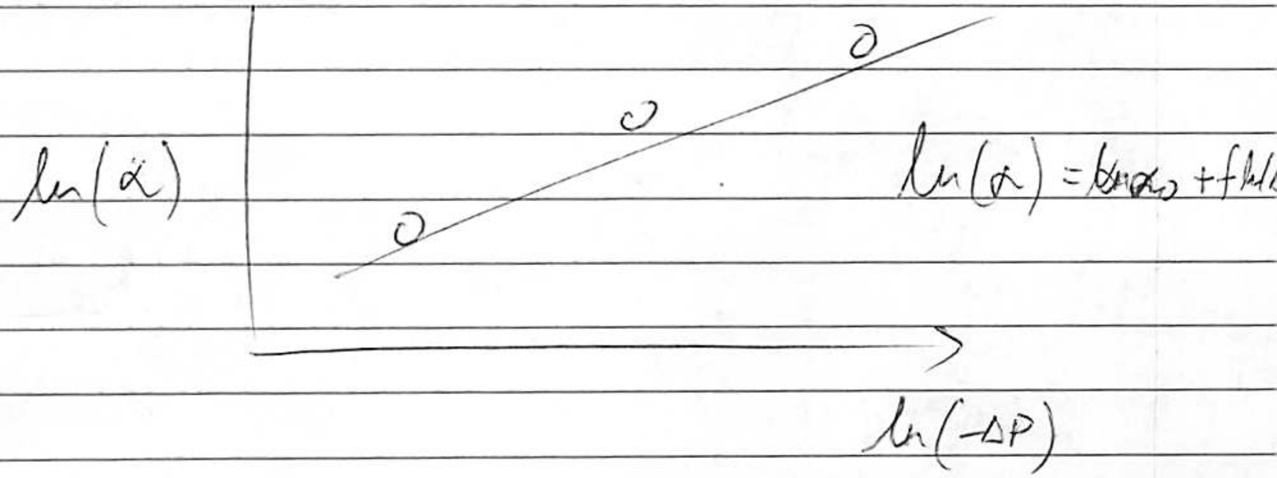
Test 3
at 370 kPa

slope = 16.3 s/L²
intercept = 10.4 s/L

$R_m = 3.35 \times 10^{11}$ 1/m
$R_c = 2.10 \times 10^{12}$ 1/m
$\alpha = 3.37 \times 10^{12}$ m/kg

Should rather use ln( )
but log( ) is OK

	log(α)	log(ΔP)
Test 1	11.90	4.56
2	12.3	5.11
3	12.5	5.57



slope = $\boxed{0.63 = f}$

intercept = 20.89

α_0 = exp(20.89) = 1.18×10^9 m/kg

Accept answers within the ranges.

See spreadsheet on course website
for plots & calculations