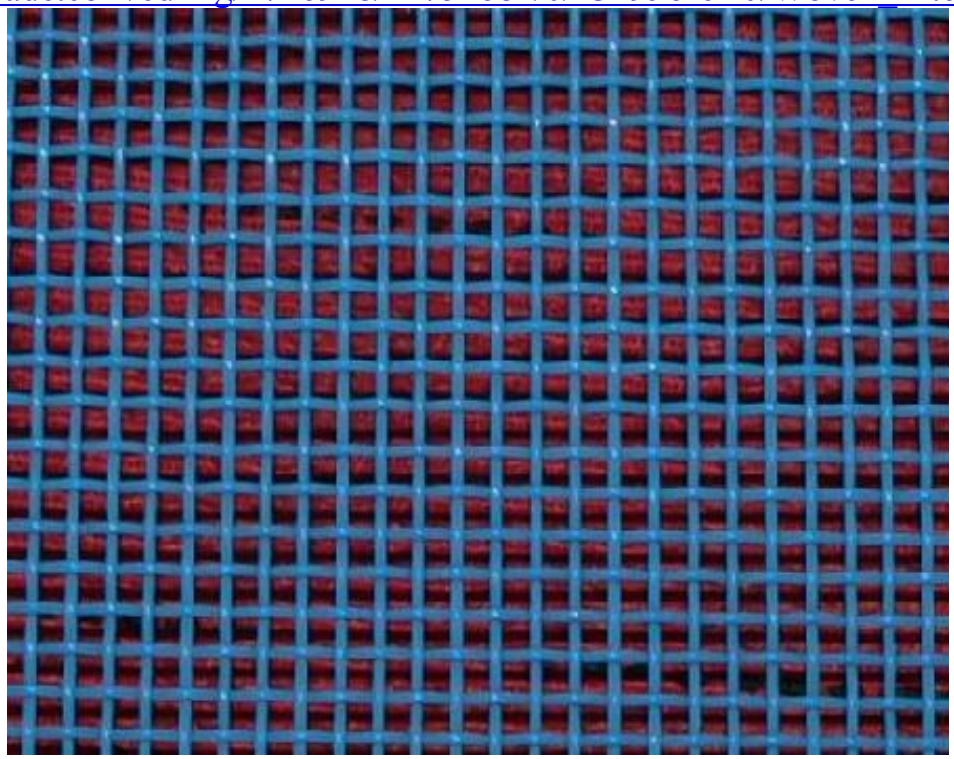
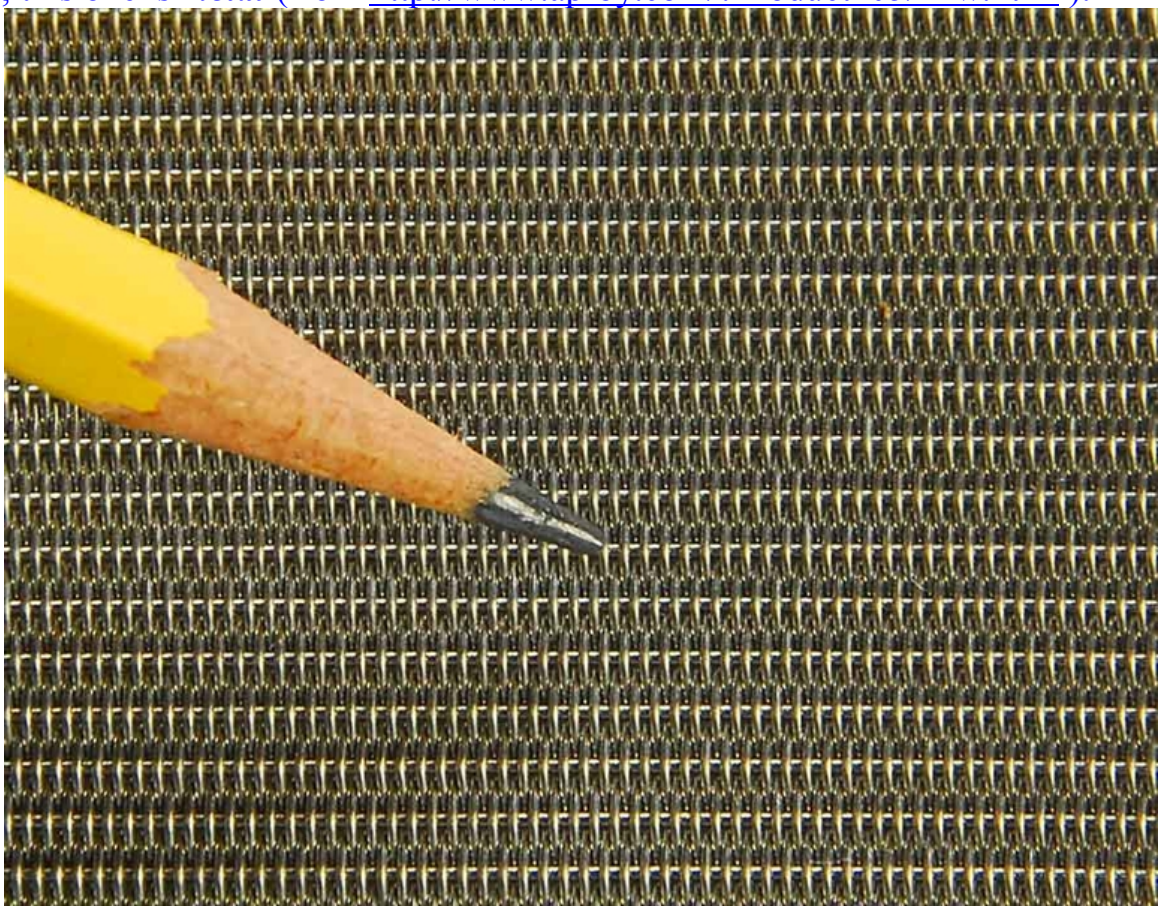
**Today, we will**:

- Discuss **air filters**, and how to classify them and analyze their efficiency
- Discuss **dust cakes** and their effect on air filters

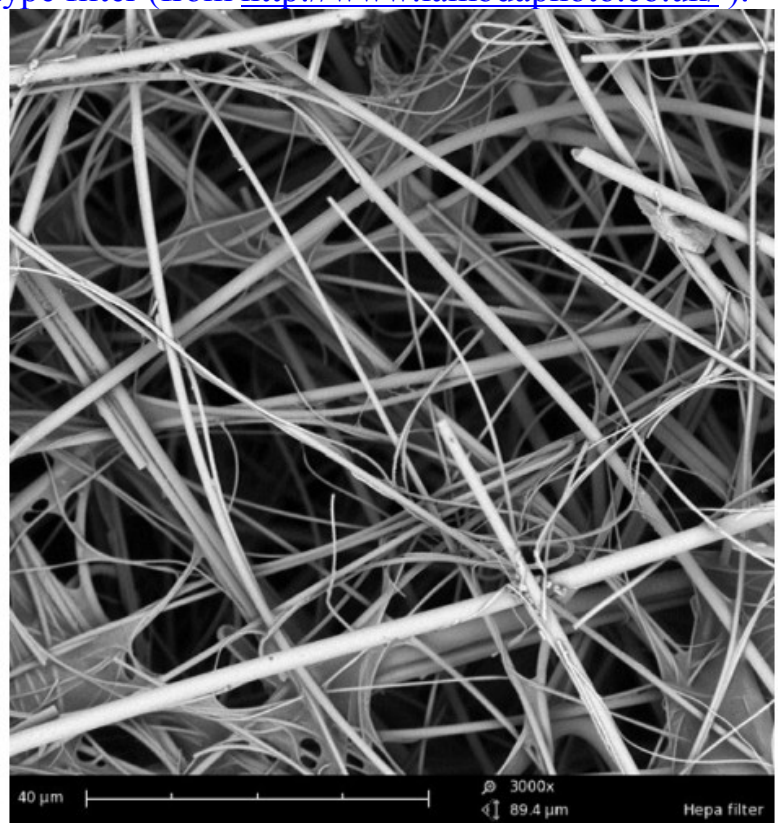
Example of a woven filter, where the woven threads are mostly just for support (from http://img.diytrade.com/cdimg/1716948/24752681/0/1329961910/Woven_filter_Belt.jpg ):



Example of a woven filter, where the woven "threads" are very tight and do the actual filtering; this one is ***metal*** (from http://www.ap-by.com/?Product105/xxw.html ):



Example of a “felt” type filter (from http://www.lambdaphoto.co.uk/ ):



**Example: Performance of an Air Filter**

**Given**: An air filter is used to clean air. Here are some properties:

- $D_f$ = 20 microns = 20E-06 m (diameter of the hairy fibers inside the filter)
- $U_0$ = 0.200 m/s (air speed upstream and downstream of the filter)
- $\varepsilon$ = 0.76 (porosity of the air filter, i.e., fraction of open area)
- $D_p$ = 1 micron = 1.0E-06 m (diameter of the air pollution particles we are targeting)
- $\rho_p$ = 1000 kg/m$^3$ (air pollution particles are treated as unit density spheres)
- $L$ = 5.0 mm = 0.0050 m (total length (thickness) of the filter)
- Air at STP: $\rho$ = 1.184 kg/m$^3$, $\mu$ = 1.849 × 10$^{-5}$ kg/(m s)

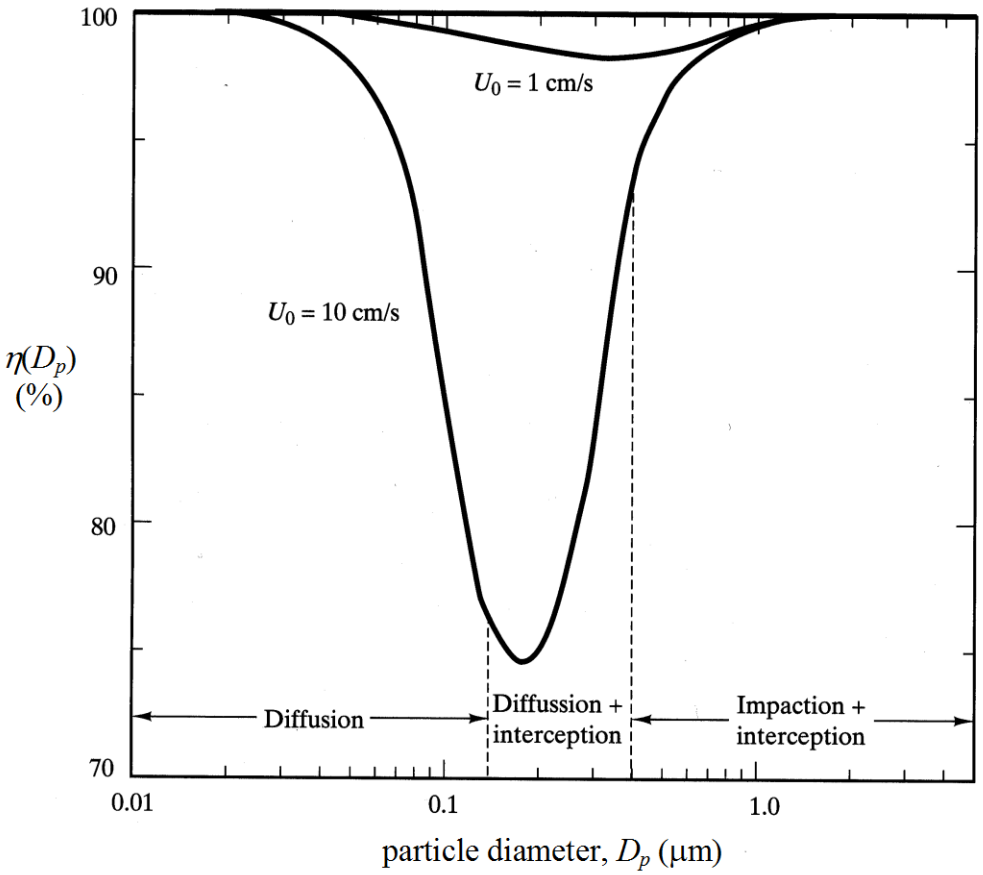
**To do**: Calculate the collection grade efficiency of the filter for these particles. You're your answer as a percentage to three significant digits.

**Solution**: Some equations: $$Stk = \frac{\left(\rho_p - \rho\right) D_p^{\,2} \left(U_0 / \varepsilon\right)}{18 \mu D_f}, \quad E_f\left(D_p\right) = \left(\frac{Stk}{Stk + 0.425}\right)^2,$$

$$L_c = \frac{\pi}{4} \frac{\varepsilon}{1-\varepsilon} \frac{D_f}{E_f\left(D_p\right)}, \quad E\left(D_p\right) = 1 - \exp\left(-\frac{L}{L_c}\right)$$

Example from a real air filter, showing the "dip" around 0.1 to 0.5 microns:

We use $E(D_p)$ instead of $\eta(D_p)$ →




Filter grade efficiency for two face velocities; filter thickness $H = 1.0$ mm, solids fraction $f_f = 0.05$ (porosity $\varepsilon = 0.95$), single fiber diameter $D_f = 2$ μm (adapted from Hinds, 1982).

**N95, N99, and N100 Face Masks**:

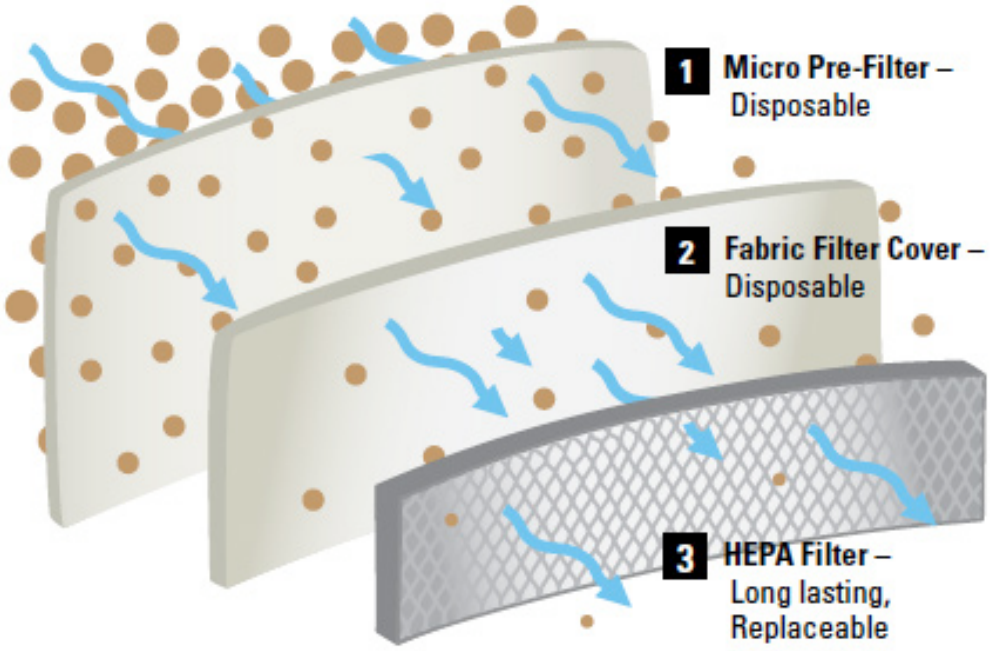
N95 N99 N100


United States NIOSH standards define the following categories of particulate filters:[http://en.wikipedia.org/wiki/Respirator - cite_note-fact_sheet-5](http://en.wikipedia.org/wiki/Respirator) (from http://en.wikipedia.org/wiki/Respirator ):

| Oil resistance | Rating | Description |
|---|---|---|
| Not oil resistant | N95 | Filters at least 95% of airborne particles |
| | N99 | Filters at least 99% of airborne particles |
| | N100 | Filters at least 99.97% of airborne particles |
| Oil Resistant | R95 | Filters at least 95% of airborne particles |
| | R99 | Filters at least 99% of airborne particles |
| | R100 | Filters at least 99.97% of airborne particles |
| Oil Proof | P95 | Filters at least 95% of airborne particles |
| | P99 | Filters at least 99% of airborne particles |
| | P100 | Filters at least 99.97% of airborne particles |

Example of a pleated filter: (from http://www.onlinevacshop.com/Fantom-HEPA-Filter.php)

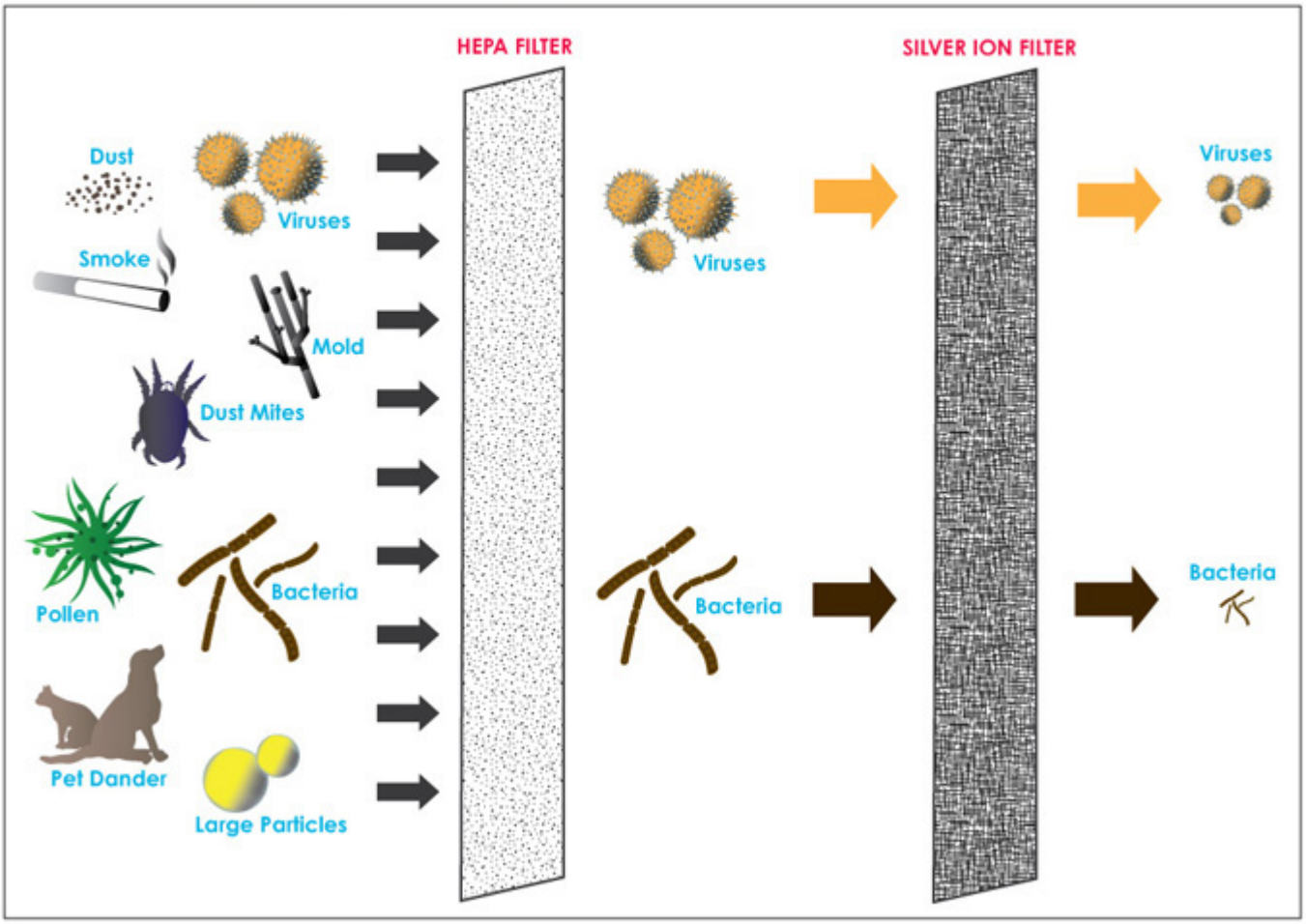

Some images from filter manufacturers:
From http://certifiedhepafilter.com/ :



From http://www.cleancraft.com/Alen_A350_Replacement_Silver_HEPA_Air_Filter_p/ap-aa350f-silv.htm :

## HEPA with Silver Ion Filtration

**The HEPA filter eliminates over 99% of airborne allergens while the addition of the Silver Ion filter eliminates 98% of bacteria and half of airborne viruses.**



Ionizer. From http://air-purifier-reviewsite.com/blog/types-of-air-purifier-technology-that-is-best-for-allergies/ :