airspeed of aircraft $= 50 \text{ m s}^{-1}$ $\quad \nu = 15 \times 10^{-6} \text{ m}^2 \text{s}^{-1}$

characteristic scale of velocity fluctuations, $u = 0.5 \text{ m s}^{-1}$, length scale $\ell = 100\text{m}$

smallest length scale $\eta = \left(\frac{\nu^3}{\epsilon}\right)^{1/4}$, $\epsilon = \frac{u^3}{\ell}$

$$= \left(\frac{\nu^3 \ell}{u^3}\right)^{1/4}$$

$$= 1.3 \text{ mm}.$$

equivalent frequency $f_\eta = \frac{50 \text{ m/s}}{1.3 \times 10^{-3}} \simeq 40 \text{ kHz}$

compare to $\frac{1}{\tau} = \left(\frac{\epsilon}{\nu}\right)^{1/2} = \left(\frac{u^3}{\ell}\frac{1}{\nu}\right)^{1/2} = 10 \text{ Hz}.$

so smallest frequency set by speed of aircraft

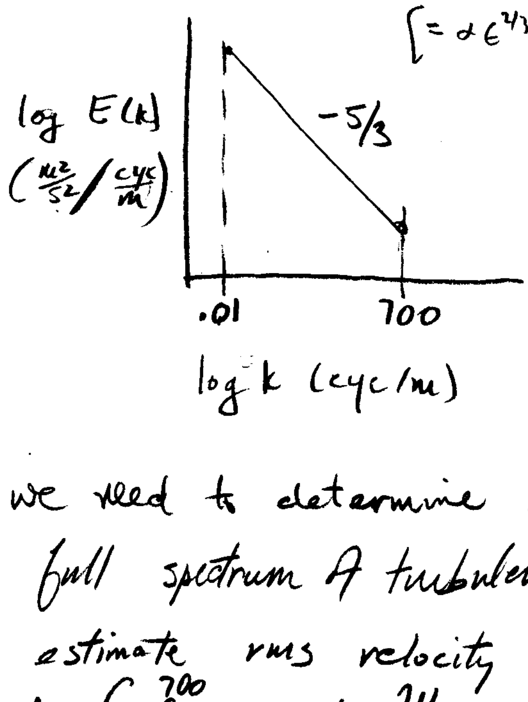
length of hot wire should be $< \frac{1}{2}(1.3 \text{ mm})$ to resolve small scales

permissible noise level?

assume spectrum of turbulence is isotropic

i.e. $E(k) = A k^{-5/3}$ $\quad (\epsilon = \text{constant})$

$[= \alpha \epsilon^{2/3} k^{-5/3}]$



.01 cyc/m → 100 m, largest scale

700 cyc/m → 1.3 mm, smallest scale

we need to determine highest permissible noise level so that full spectrum of turbulence can be resolved.

estimate rms velocity — or turbulent velocity fluctuations by $\left[\int_{.01}^{700} E(k)\, dk\right]^{1/2}$

$$\int_{.01}^{700} E(k)\,dk = \int_{.01}^{700} A k^{-5/3}\,dk \qquad (A = \alpha \epsilon^{2/3} \text{ in T+L})$$

$$= A \frac{k^{-2/3}}{-2/3} \Big|_{.01}^{700}$$

$$= -\frac{3}{2} A \left[(700)^{-2/3} - (.01)^{-2/3} \right]$$

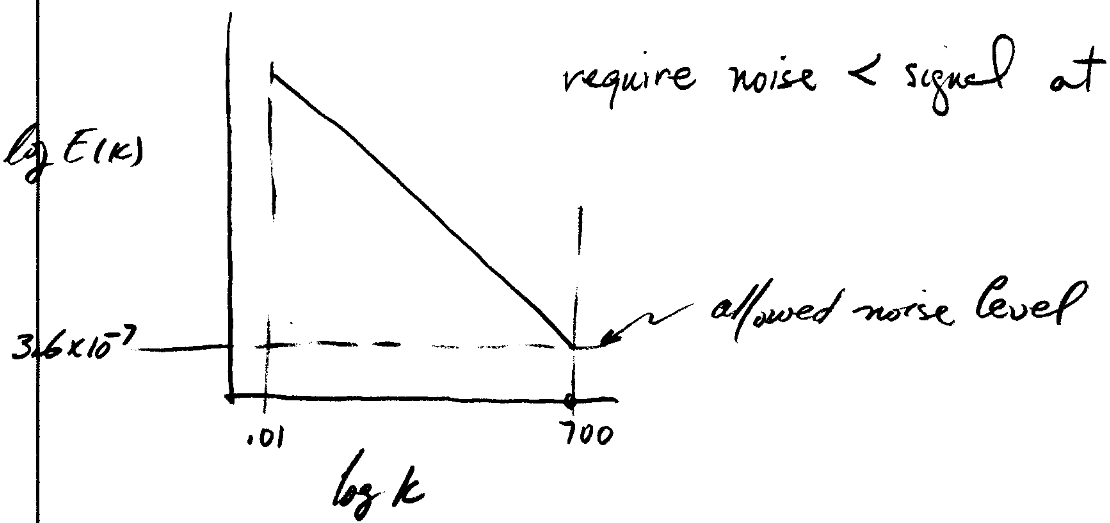
$$= -\frac{3}{2} A \left\{ \sim .01 + 21.54 \right\}$$

compare to $u = 0.5$ m/s, characteristic velocity scale. This will give us an estimate for the constant $A = \alpha \epsilon^{2/3}$

$$0.5^2 = +\frac{3}{2} A (21.53) \longrightarrow A = \cancel{.02}\ .01$$

at $k = 700 \frac{cyc}{m}$, $E(k) = .01 (700)^{-5/3} \sim 2 \times 10^{-7} \left[\frac{m^2/s^2}{(cyc/m)} \right]$

require noise < signal at 700 $\frac{cyc}{m}$



assume white noise from $k = .01$ to $k = 700$

then $u^2_{noise} = \int_{.01}^{700} (3.6 \times 10^{-7})\,dk = 3.6 \times 10^{-7} (700 - .01)$

$$= 1.5 \times 10^{-4}\ m^2/s^2$$

and $\boxed{u_{noise} = .01\ m/s \quad (\sim 1\ cm/s)}$