Radiation Biology, Protection and Applications

(PHYS-450)

EXERCISES

Week 12

Topic: Industrial Applications: **Gauges**

Problem 1:

Show why the maximum sensitivity of a level gauge is obtained for $\mu \cdot x = 1$.

Problem 2:

A smoke detector contains a ^{241}Am source with an activity of 30kBq. (This is the typical range.) What is the mass of the ^{241}Am?

Topic: Industrial Applications of tracer techniques to fluid dynamics

Assume in all of the following exercises that the transit time of the radiotracer through the system is very short in comparison to its half life, so that nuclear decays of the tracer in the system can be neglected.

Problem 3:

Show that the detector response at B (see Figure on slide 6 of lecture WEEK 12b) is a direct measure of the RTD of tracer particles, provided that:

- the tracer is injected as an instantaneous pulse, and
- the flow rate Q through the system is constant.

Problem 4:

Show that (using the tracer dilution method) the flow rates Q for the total sample method and the total count method are given by $Q = qA_T/a$ and $Q = A_TF/N$, respectively. (A_T = activity of the tracer, q = sampling rate, a = tracer activity in the sample, F = calibration factor, N = total number of counts).

Problem 5:

Show that, after an instantaneous pulse at the inlet, the tracer concentration will decrease exponentially in a rapidly stirred tank. Assume a constant flow rate through the tank.

Problem 6:

Show that the MRT for tracer particles between injection and monitoring is given by (Q = flow rate, N_r = total number of tracer particles injected, $C(t)$ = tracer concentration at B at time t):

$$MRT = \frac{Q}{N_T} \int_0^\infty t \cdot C(t)\, dt$$