ENAE 483/788D CREW SYSTEMS SPECIALTY PROBLEMS – FALL, 2022

(1) Calculate the decompression R-values for each of the following transitions

(a) From a Soyuz capsule (14.7 psi, 21% O_2) to an Apollo capsule (5 psi, 100% O_2)

$$R = \frac{pp_{N_2\ start}}{P_{final}} = \frac{0.79(14.7)}{5} = \boxed{2.323}$$

(b) From an Apollo capsule at launch (14.7 psi, 21% O_2) to the same capsule when it has a cabin depressurization just as it reaches orbit and the crew are in their spacesuits (3.5 psi, 100% O_2)

$$R = \frac{pp_{N_2\ start}}{P_{final}} = \frac{0.79(14.7)}{3.5} = \boxed{3.318}$$

(c) From a Dragon capsule breathing a Nitrox mix (14.7 psi, 30% O_2) to a Dragon launch and entry suit after an emergency depressurization, also on Nitrox (5 psi, 80% O_2)

$$R = \frac{pp_{N_2\ start}}{P_{final}} = \frac{0.6(14.7)}{5} = \boxed{1.764}$$

(d) From a habitat at Earth sea level pressure (14.7 psi, 21% O_2) to a Russian Orlan pressure suit at Stage I (6.7 psi, 100% O_2)

$$R = \frac{pp_{N_2\ start}}{P_{final}} = \frac{0.79(14.7)}{6.7} = \boxed{1.733}$$

(e) From a lunar habitat at reduced pressure (10.4 psi, 32% O_2) to a U.S. advanced pressure suit (8.3 psi, 50% O_2)

$$R = \frac{pp_{N_2\ start}}{P_{final}} = \frac{0.7(10.2)}{4.3} = \boxed{1.661}$$

(2) Generate a plot of tissue nitrogen vs. time similar that that on page 40 of the lecture slides, using the Haldane equation from page 26. Note that all of the pressure terms in the Haldane equation refer to partial pressures of N_2 in the air and the tissues. Values of $P(0)$ refer to conditions just after a step-wise change in pressure - for example, transitioning from cabin atmosphere to suit atmosphere. Assume four tissue groups of 30, 60, 120, and 240 minutes. Assume the initial conditions are a spacecraft cabin atmosphere of 14.7 psi pressure and 21% ppO_2, and transitioning to an EVA suit at 4.3 psi and 100% O_2. Just use the appropriate cabin ppN_2 atmosphere conditions for the term $P_{alveoli}$ (i.e., don't bother to apply the corrections for water vapor pressure and CO_2 content at the bottom of page 26). How long will it take until all tissues are below the R=1.4 limit?

$$k_{30} = \frac{\ln 2}{30} = 0.02310\ min^{-1};\quad k_{60} = \frac{\ln 2}{60} = 0.01155\ min^{-1}$$
$$k_{120} = \frac{\ln 2}{120} = 0.005776\ min^{-1};\quad k_{240} = \frac{\ln 2}{240} = 0.002888\ min^{-1}$$

$$P_{\text{tissue}}(t) = P_{\text{tissue}}(0) + [P_{\text{alveoli}}(0) - P_{\text{tissue}}(0)]\left(1 - e^{-kt}\right)$$
$$P_{\text{tissue}}(0) = 0.7(10.2) = 7.14\ psi; \quad P_{\text{alveoli}}(0) = 0$$
$$P_{\text{tissue}}(t) = P_{\text{tissue}}(0)e^{-kt}$$

For an initial ppN_2 *in the bloodstream of 7.14, you fall below R=1.4 when the* $P_{tissue} \leq 7.14/1.4 = 5.1$ *psi. As shown in the following chart, this occurs last for the 240 min tissue at about 115 minutes.*

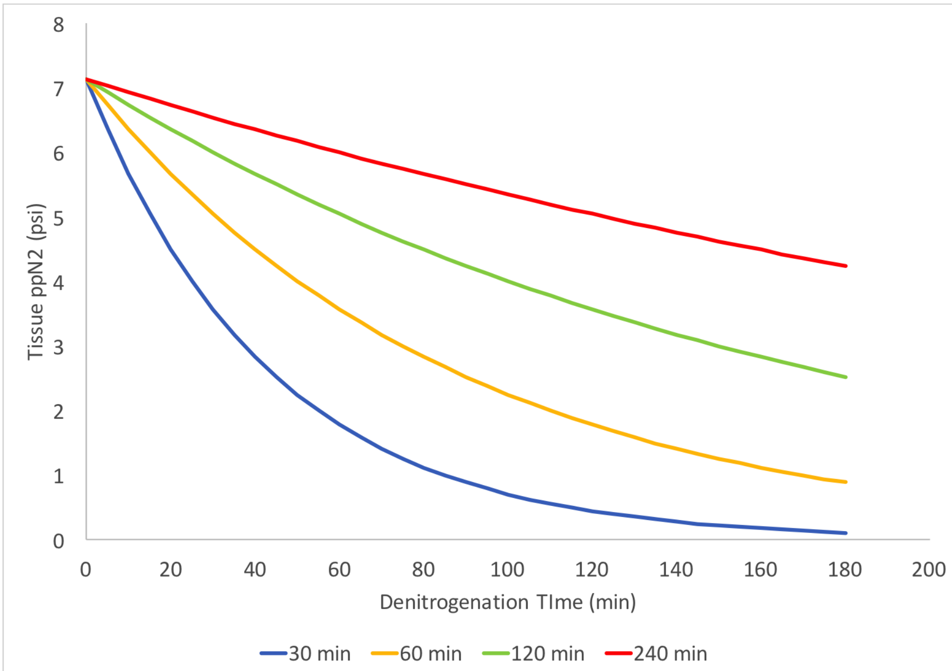

FIGURE 1. default

(3) You would like to generate 1 Earth gravity (9.8 m/sec^2) in a space settlement.

(a) If the residents can tolerate 4 rpm, what is the required radius of the spinning habitat?

$$\omega = (4\ rpm)\frac{2\pi\ rad/rev}{60\ sec/min} = 0.4189\ rad/sec$$
$$a_{centripetal} = \omega^2 r \Longrightarrow r = \frac{a_{centripetal}}{\omega^2} = \frac{9.8}{0.4189^2} = \boxed{55.85\text{ m}}$$

(b) There is a running course around the largest circumference of the settlement. Two runners each run at a six-minute mile pace, one in the direction of rotation and the other in the opposite direction. What gravity level does each runner feel?

$$v_{track} = \omega r = 0.4189(55.85) = 23.40\ m/sec$$
$$v_{run} = 6\ min/mile \Longrightarrow \frac{1607\ m/mile}{60\ sec/min(6\ min/mile)} = 4.464\ m/sec$$

$$g = \frac{v^2}{r} = \frac{(23.40 \pm 4.464)^2}{55.85}$$
$$g_{pro-spin} = \boxed{13.08 \text{ m/sec=1.419 g}}$$
$$g_{anti-spin} = \boxed{6.420 \text{ m/sec=0.6551 g}}$$