Series 1 (18 February 2025)

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Chapter 1.3: Introduction to the CV system

Exercise 1.3.1

If we admit that the cardiac ejection lasts ⅓ of the cardiac cycle and the blood flow in the capillaries and the veins is continuous, determine the mean blood velocity in the aorta, the capillaries and the venae cavae of an adult in repose.
(For the aorta, determine the mean velocity during the systolic phase).

Exercise 1.3.2

Calculate the order of magnitude of time a blood particle needs to traverse the whole arterial and venous circulation.

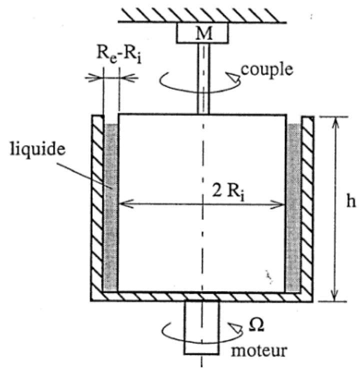
Exercise 1.3.3

Determine the arterial and venous pressure in the raised hand and in the foot of a standing adult. If the wall of the blood vessels is elastic, what conclusion can you draw? Imagine the mechanisms assuring the venous return.

Chapter 1.4: Blood Rheology

Exercise 1.4.1

A Couette-type viscometer, used to measure the viscosity of a Newtonian fluid, is shown in the Figure.



(**a**) Show that the exact expression relating viscosity, μ, to torque, M, and rotational speed, Ω, is given by:

$$\mu = \frac{M(R_e^2 - R_i^2)}{4\pi\Omega h R_i^2 R_e^2}$$

Hint: Start from the Navier-Stokes equations in cylindrical coordinates and integrate them under the appropriate boundary conditions to derive the velocity distribution v_θ as a function of r. Then use the relation for the shear stress:

$$\tau = \mu\gamma = \mu\left[r\frac{\partial}{\partial r}\left(\frac{v_\theta}{r}\right)\right]_{r=R_i}$$

and the equilibrium of torques to obtain the final expression for μ.

(**b**) Find an approximate expression for the shear stress, τ, assuming a linear velocity profile, and compare with the exact solution.