Practical problems /use numerical methods/:

1. Find out the maximal speed which can be gained by a locomotive with the motive force of 25 ton *(1 ton of force = 9800 N)* if the total mass of the cars is 2000 tons? Consider the friction force noting that $F_{fr} = A\cdot v + B\cdot v^3$. Assume that $A = 10^4$ *kg/s*, and $B = 30$ *kg·s/m²*. What power of the locomotive is? Find out how the speed would depend on the motive force and coefficients *A, B*?
2. Find a uniform motion velocity of a boat assuming that the friction force is $F_{fr} = A\cdot v + B\cdot v^3$ with $A = 40$ *kg/s*, $B = 32$ *kg·s /m²*. Vary the motive force provided by a couple of boaters from 10 to 1000 *N*. Plot velocity vs motive force.
3. Find a uniform motion velocity of a motorboat assuming that the friction force is $F_{fr} = A\cdot v + B\cdot v^3$ with $A = 40$ *kg/s*, $B = 32$ *kg·s /m²*. Vary the power of the motor from 0.2 to 6 *kW*. Plot velocity vs power.
4. An ocean greyhound has a tonnage of 20 000 ton and a power engine with the power of 15 000 kW. Find out its maximal velocity if the friction force is given by $F_{fr} = A\cdot v + B\cdot v^3$ with $A = 1.5\cdot 10^4$ *kg/s*, $B = 1.3\cdot 10^3$ *kg·s /m²*.

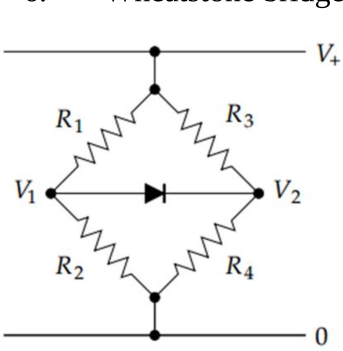
5. * The Lagrange point problem. /from *Computational Physics* by Mark Newman/

There is a magical point between the Earth and the Moon, called the L_1 Lagrange point, at which a satellite will orbit the Earth in perfect synchrony with the Moon, staying always in between the two. This works because the inward pull of the Earth and the outward pull of the Moon combine to create exactly the needed centripetal force that keeps the satellite in its orbit. Assuming circular orbits, and assuming that the Earth is much more massive than either the Moon or the satellite, show that the distance r from the center of the Earth to the L_1 point satisfies the following eq.:

$$\frac{GM}{r^2} - \frac{Gm}{(R-r)^2} = r\omega^2,$$

where M and m are the Earth and Moon masses, G is Newton's gravitational constant, R is the distance between the Earth and the Moon, and ω is the angular velocity of both the Moon and the satellite. Write a program (using root-finding methods) to solve for the distance r from the Earth to the L_1 point.

6. * Wheatstone bridge problem /from *Computational Physics* by Mark Newman/



Consider a simple circuit, which is a variation on the classic Wheatstone bridge. The resistors obey the normal Ohm law, but the diode obeys the diode equation:

$$I = I_0\left(e^{\frac{V}{V_T}} - 1\right),$$

where V is the voltage across the diode and I_0 and V_T are constants.

Write down Kirchhoff's current law for points V_1 and V_2, and solve the two nonlinear equations for the voltages V_1 and V_2 if: $V_+ = 5$ V, $R_1 = 1$ kΩ, $R_2 = 4$ kΩ, $R_3 = 3$ kΩ, $R_4 = 2$ kΩ, $I_0 = 3$ nA, $V_T = 0.05$ V.