

1. **Epidemic models with vital dynamics.** Alternative family of epidemic models introduces the birth and the death processes in the population, with newborns becoming susceptible. This is called vital dynamics. Let μ be the birth rate, and ν the death rate (people die at this rate regardless of their current category). For a constant population we can set $\mu = \nu$. For your homework, extend:

- SIRS ($S \xrightarrow{\beta} I \xrightarrow{\gamma} R \xrightarrow{\eta} S$), and
- SEIRS ($S \xrightarrow{\beta} E \xrightarrow{\sigma} I \xrightarrow{\gamma} R \xrightarrow{\eta} S$)

fully-mixed models with the vital dynamics. The rates to switch between different population categories are written over the arrows. Note also, that in the SEIRS model, category E serves only as a delay (incubation time) as once when people are exposed they will ultimately become infected.

Start by writing the differential equations and then solve the systems numerically, e.g., by using `scipy.integrate` initial value problem function. Explore different setting for the rate parameters. Plot the temporal evolution of the population fractions belonging to different categories. Discuss your results.