# AGLA Assigment 3 Report

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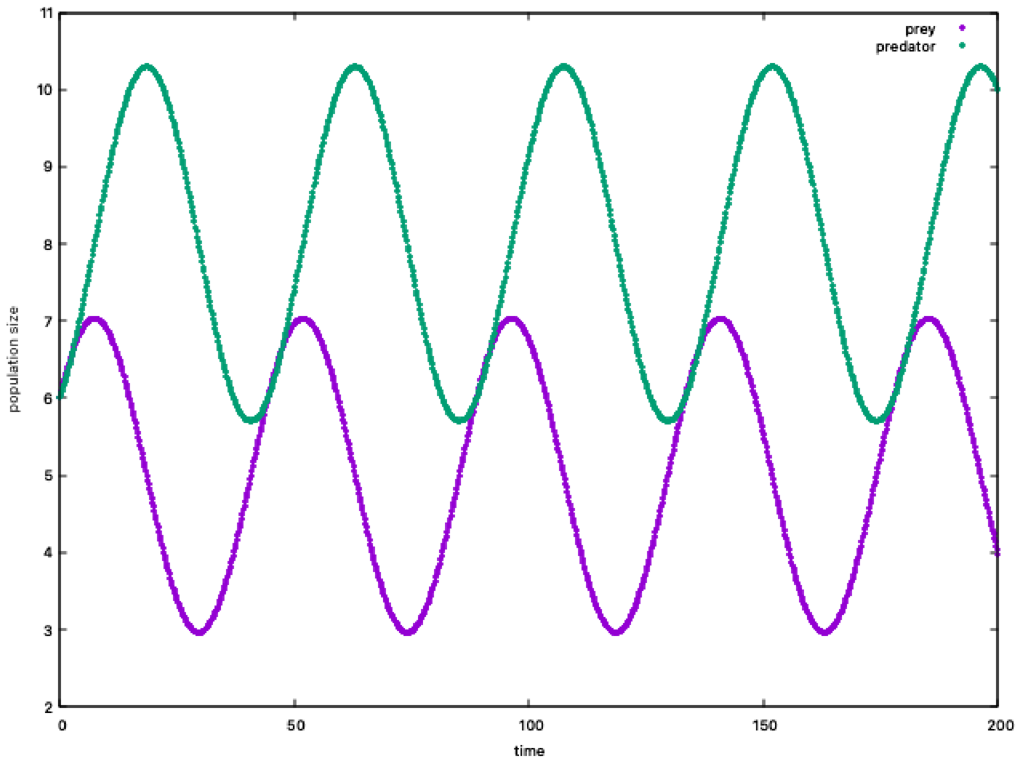
May 5, 2023

## Predator-Prey Model

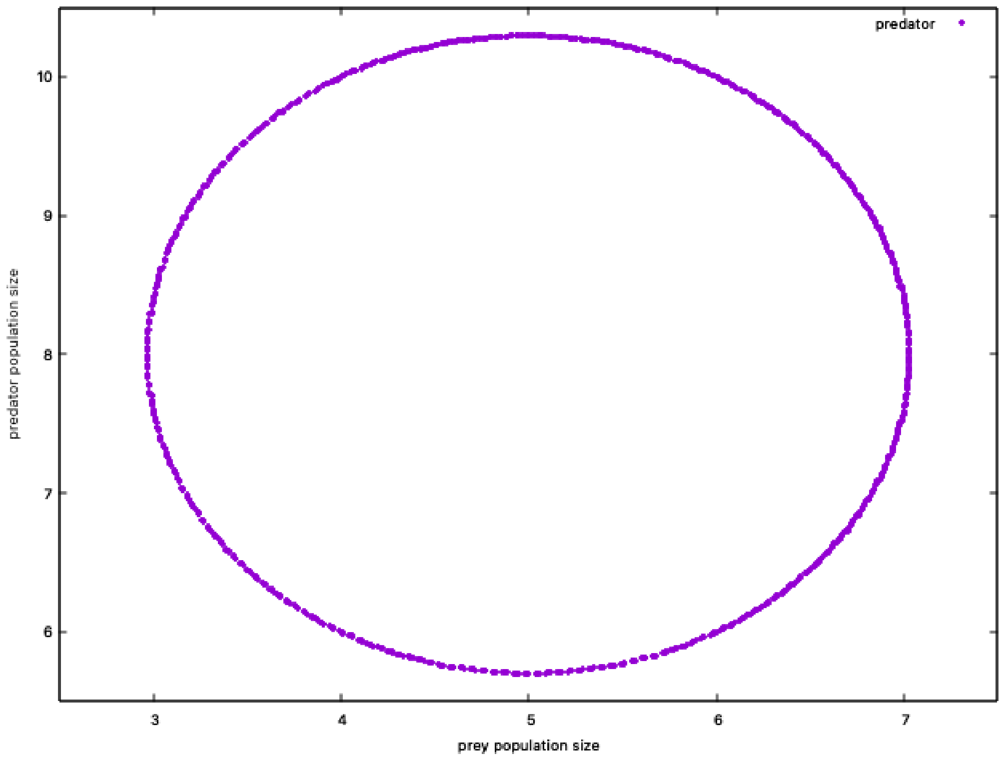
### k(t), v(t)

```
gnuplot> set xlabel "time"
gnuplot> set ylabel "population size"
gnuplot> plot
    "vt.dat" with points pt 7 ps 0.5 title "prey",
    "kt.dat" with points pt 7 ps 0.5 title "predator"
```



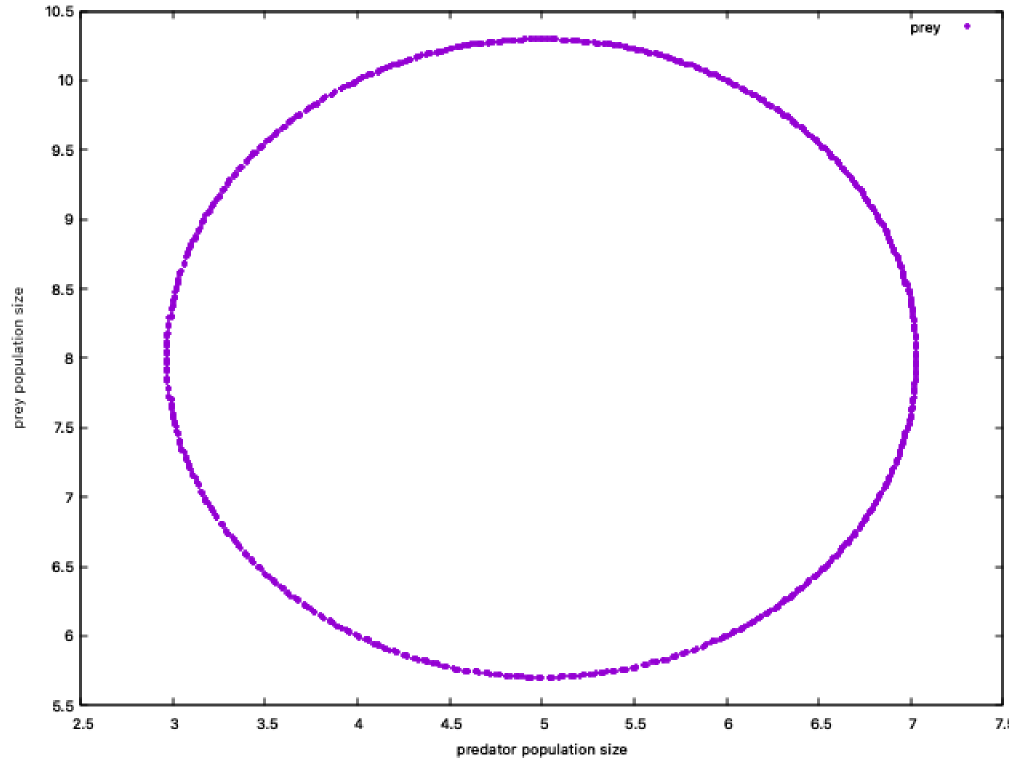
## k(v)

```
gnuplot> set xlabel "prey population size"
gnuplot> set ylabel "predator population size"
gnuplot> plot "kv.dat" with points pt 7 ps 0.5 title "predator"
```




## v(k)

```
gnuplot> set xlabel "predator population size"
gnuplot> set ylabel "prey population size"
gnuplot> plot "vk.dat" with points pt 7 ps 0.5 title "prey"
```




## Code

```
int main() {
    // Specify Output Format
    std::cout.setf(std::ios::fixed, std::ios::floatfield);
    std::cout.precision(2);

    // Input Parameters
    double alpha_1, alpha_2, beta_1, beta_2, v_0, k_0, t;
    int n;
    std::cin >> v_0 >> k_0 >> alpha_1 >> beta_1 >> alpha_2 >>
    beta_2 >> t >> n;


    double sample_time_span = t / n;
    double alpha_root = std::sqrt(alpha_1 * alpha_2);
    double predator_rate = (beta_1 * std::sqrt(alpha_2)) / (beta_2
    * std::sqrt(alpha_1));
    double prey_rate = 1 / predator_rate;

    // U = [V, K, 1], U0 = [V0, K0, 1], V0 = v_0 - alpha_2/beta_2,
    K0 = k_0 - alpha_1/beta_1;
    // U(t) = eAt*U0

    // dU = A(2x2) *u(2x1) + b(2x1); => dU = A(3x3)*u(3x1);
```

```
// dU = [ a1  a2  a3          [ v
//        a4  a5  a6     *      k
//         0   0   0 ]          1 ]

Matrix<double> *U_0 = new ColumnVector<double>(3);

U_0->Put(0, 0, v_0 - alpha_2 / beta_2);
U_0->Put(1, 0, k_0 - alpha_1 / beta_1);
U_0->Put(2, 0, 1);


// Coefficients from analytical solution of ODE in general form
auto eA = [alpha_root, predator_rate, prey_rate, alpha_2,
beta_2, alpha_1, beta_1](double t) {
    auto m = new SquareMatrix<double>(3);

    // Prey gain from their population
    m->Put(0, 0, std::cos(alpha_root * t));
    // Prey lose from meetings with predators
    m->Put(0, 1, -predator_rate * std::sin(alpha_root * t));
    // Free coefficient in ODE
    m->Put(0, 2, alpha_2 / beta_2);

    // Predators gain from meetings with preys
    m->Put(1, 0, prey_rate * sin(alpha_root * t));
    // Predators lose from their population
    m->Put(1, 1, cos(alpha_root * t));
    // Free coefficient in ODE
    m->Put(1, 2, alpha_1 / beta_1);

    // Last row 0-s
    m->Put(2, 0, 0);
    m->Put(2, 1, 0);
    m->Put(2, 2, 0);

    return m;
};

auto time_series = std::vector<double>(n+1, 0);
auto prey_population = std::vector<double>(n+1, 0);
auto predator_population = std::vector<double>(n+1, 0);

for (int i = 0; i < n + 1; i++) {
    auto ti = sample_time_span * i;

    auto eAt = eA(ti);
    auto Ui = *eAt * U_0;

    time_series[i] = ti;
    prey_population[i] = Ui->Get(0, 0);
    predator_population[i] = Ui->Get(0, 1);

    free({eAt, Ui});
}

std::cout << "t:" << std::endl;
for (auto x: time_series) std::cout << x << " ";
```

```
    std::cout << std::endl;

    std::cout << "v:" << std::endl;
    for (auto x: prey_population) std::cout << x << " ";
    std::cout << std::endl;

    std::cout << "k:" << std::endl;
    for (auto x: predator_population) std::cout << x << " ";
    std::cout << std::endl;

    free({U_0});
    return 0;
}
```

Complete code available here: : Github