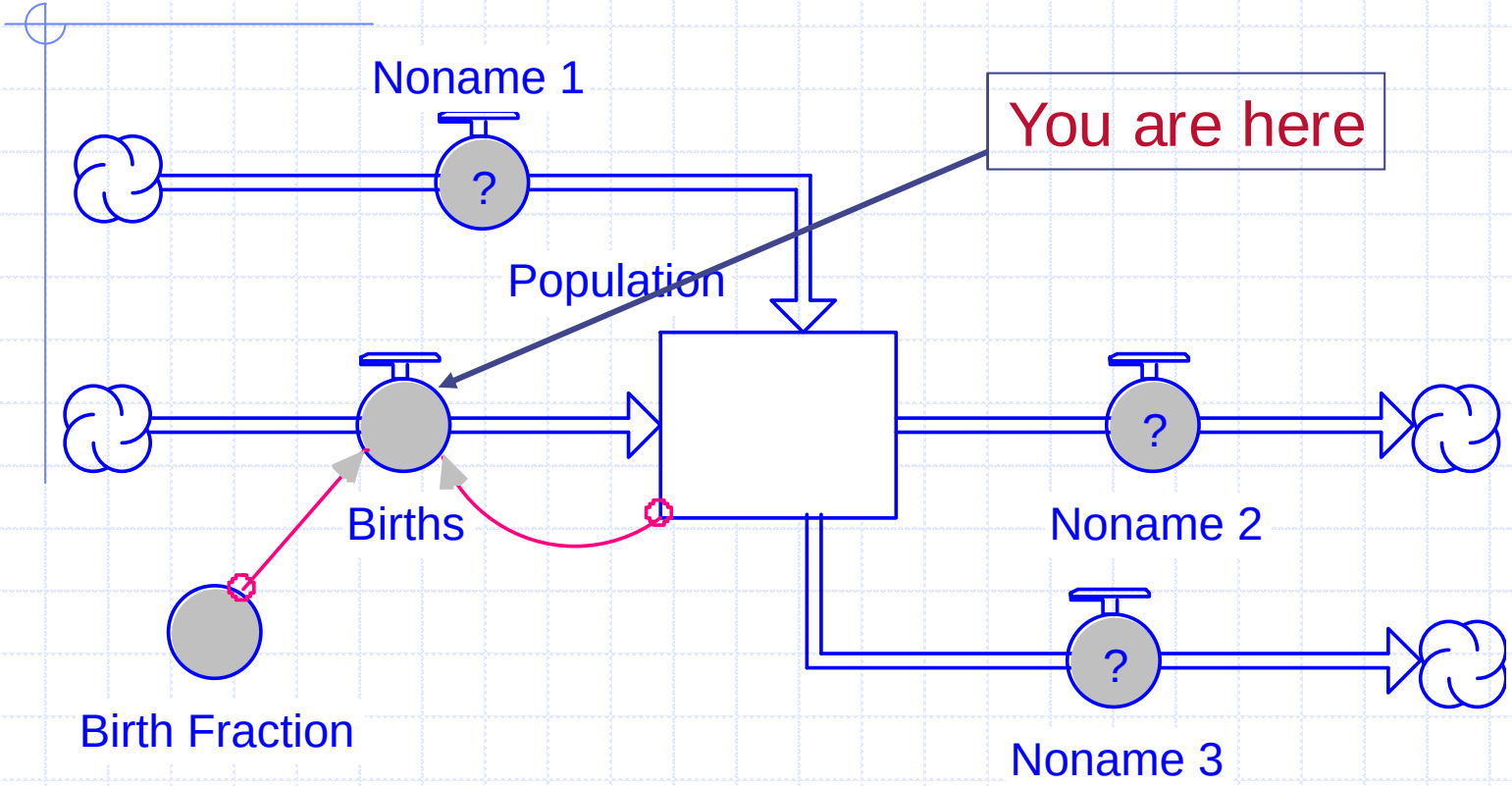
Positive Feedback Explained



Births = Birth_Fraction * Population

Birth_Fraction = c, a positive constant

Isolate Feedback Loop

- Assume all other flows remain unchanged.
- Check how change in Population affects flow in question.
- Is Population change reinforced or counteracted by change in flow?
- Reinforced = positive feedback.
- Counteracted = negative feedback.

Positive Feedback – Pop Increase

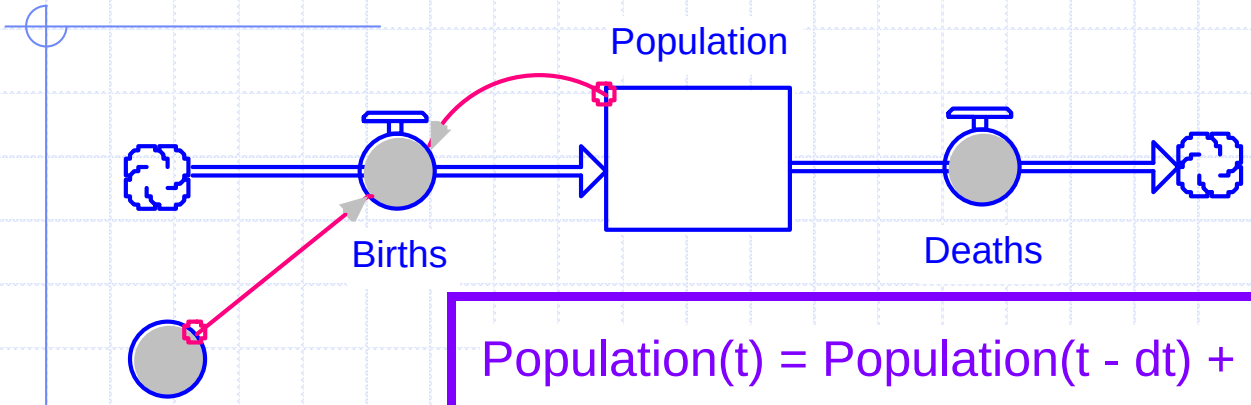


Table 1

Note numbers

Population(t) = Population(t - dt) + (Births - Deaths) * dt
INIT Population = 1000

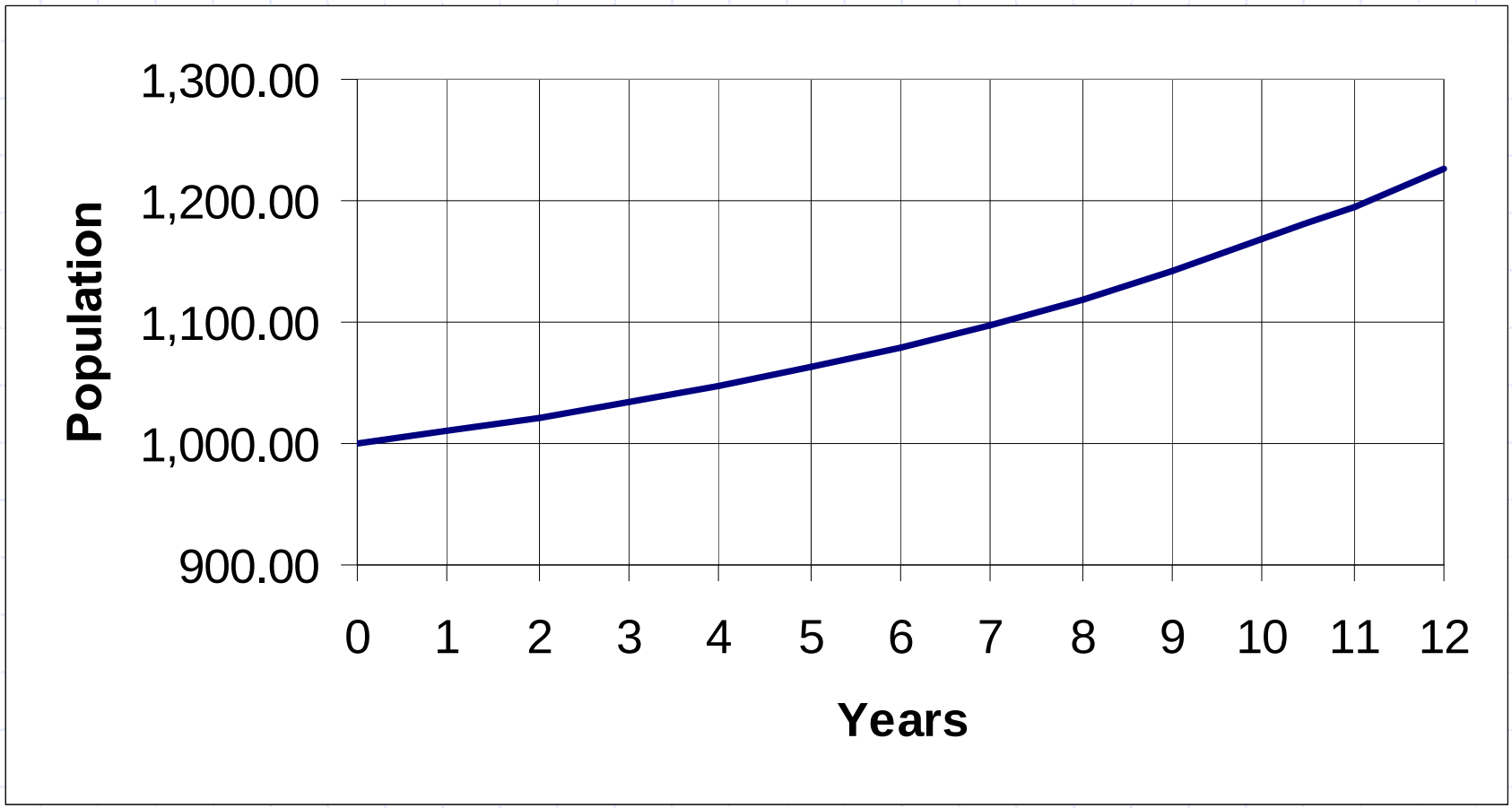
INFLOWS:
Births = Birth_Fraction*Population
OUTFLOWS:
Deaths = 100
Birth_Fraction = .11

Population Table

- Population increases.
- All flows except Birth remain unchanged.
- Birth inflow increases.
- Population increases even more.
- Reinforces increase.
- Thus, positive feedback.

Time	Population
0	1,000.00
1	1,010.00
2	1,021.10
3	1,033.42
4	1,047.10
5	1,062.28
6	1,079.13
7	1,097.83
8	1,118.59
9	1,141.64
10	1,167.22
11	1,195.61
Final	1,227.13

Graph of Population



Description of Graph

- Increasing
- Increasing at an increasing rate
  - Concave up
- NOT leveling off
  - Would have to change concavity

What will happen to the population if this continues?

When Population Increases

- Population increases by ΔP.
  - To $P + \Delta P$.
- Hold other flows unchanged.
  - ΔP = Births + (all other flows in/out: constant)
  - So without any changes in Birth inflow, Population will again increase by ΔP.
- Births = Birth_Fraction* $(P + \Delta P)$.
  - Births increase by Birth_Fraction * ΔP.
- Population increases by more than ΔP.
  - By ΔP + Birth_Fraction * ΔP
- Reinforces increase in Population.

Positive Feedback – Pop Decrease

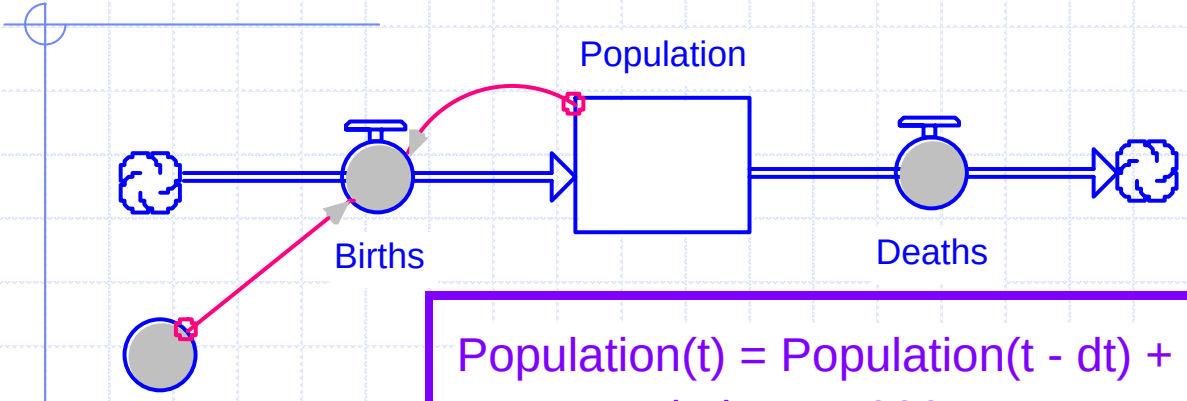


Table 1

Population(t) = Population(t - dt) + (Births - Deaths) * dt
INIT Population = 1000

INFLOWS:
Births = Birth_Fraction*Population
OUTFLOWS:
Deaths = 120
Birth_Fraction = .11

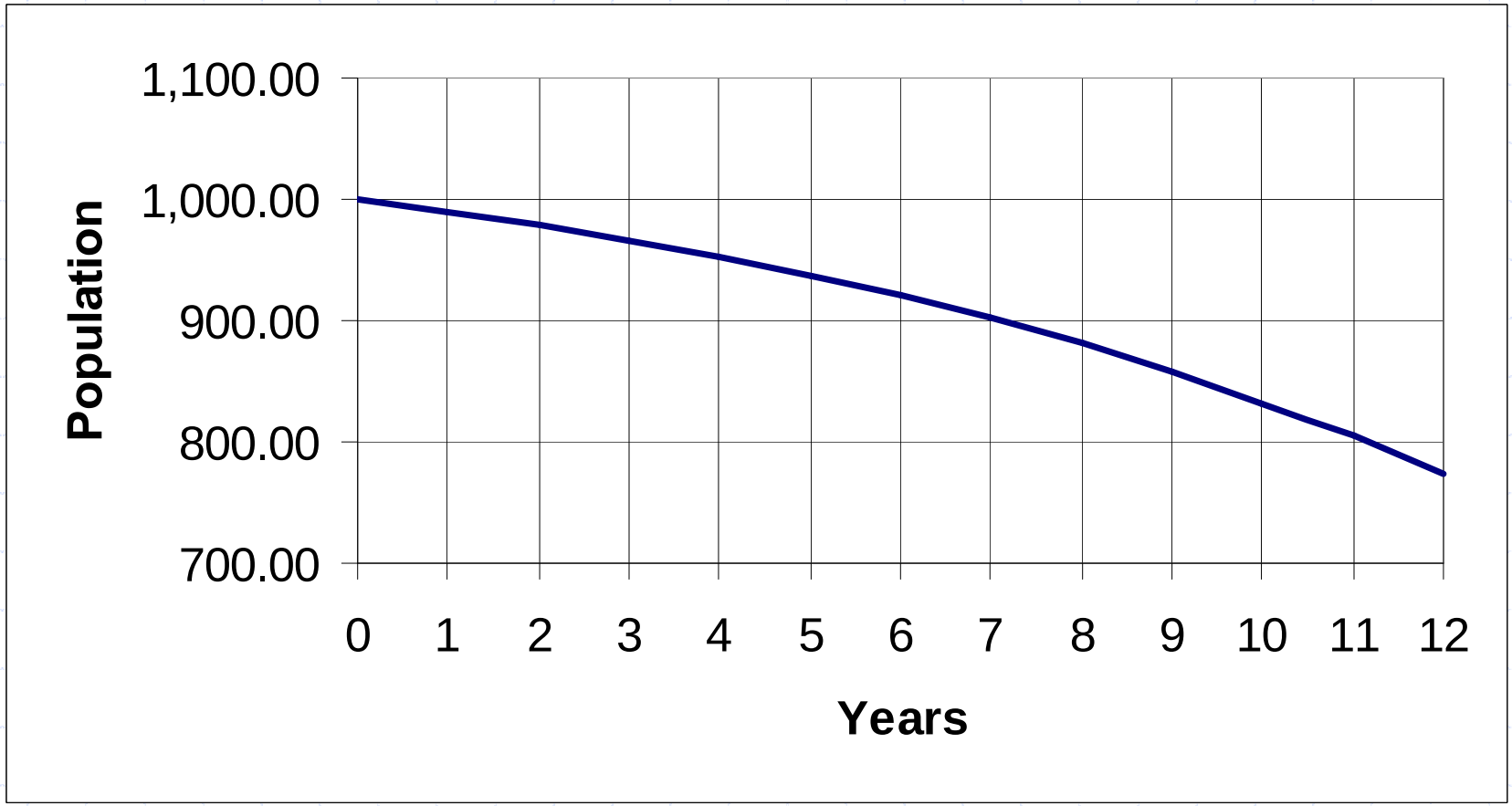
Note change

Population Table

- Population decreases.
- All flows except Birth remain unchanged.
- Birth inflow decreases.
- Population decreases even more.
- Reinforces decrease.
- Thus, positive feedback.

Time	Population
0	1,000.00
1	990.00
2	978.90
3	966.58
4	952.90
5	937.72
6	920.87
7	902.17
8	881.41
9	858.36
10	832.78
11	804.39
Final	772.87

Graph of Population



Description of Graph

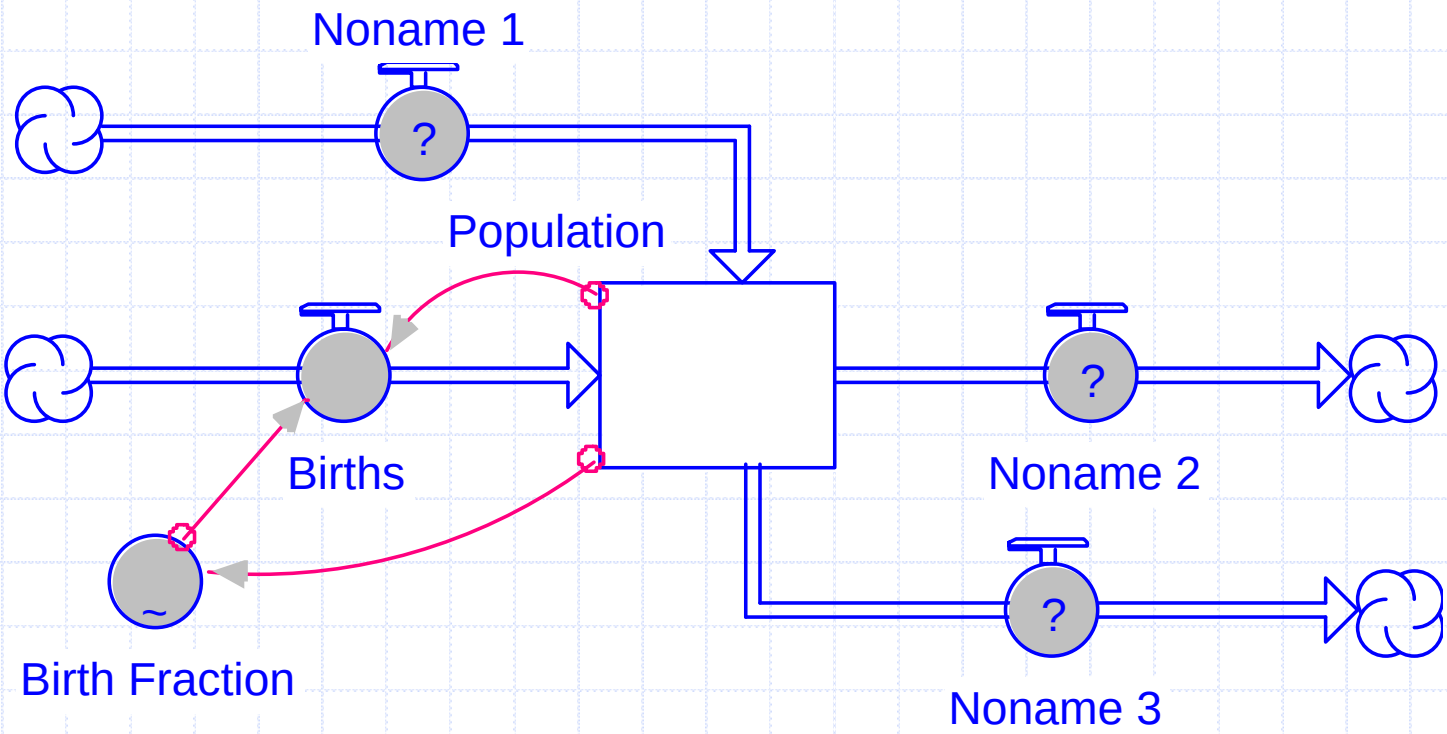
- Decreasing
- Decreasing at an increasing rate
  - Concave down
- NOT leveling off
  - Would have to change concavity

What will happen to the population if this continues?

When Population Decreases

- Population decreases by $|\Delta P|$.
  - To $P + \Delta P$.
- Hold other flows unchanged.
  - ΔP = Births + (all other flows in/out: constant)
  - So without any changes in Birth inflow, Population will again decrease by $|\Delta P|$.
- Births = Birth_Fraction* $(P + \Delta P)$.
  - Births decrease by $|\text{Birth\_Fraction} * \Delta P|$.
- Population decreases by more than $|\Delta P|$.
  - By $|\Delta P + \text{Birth\_Fraction} * \Delta P|$.
- Reinforces decrease in population.

Negative Feedback Explained



Births = Birth_Fraction * Population

Birth_Fraction = graph(population), decreasing

Isolate Feedback Loop

- Assume all other flows remain unchanged.
- Check how change in Population affects flow in question.
- Is population change reinforced or counteracted by change in flow?
- Reinforced = positive feedback.
- Counteracted = negative feedback.

Negative Feedback – Pop Increase

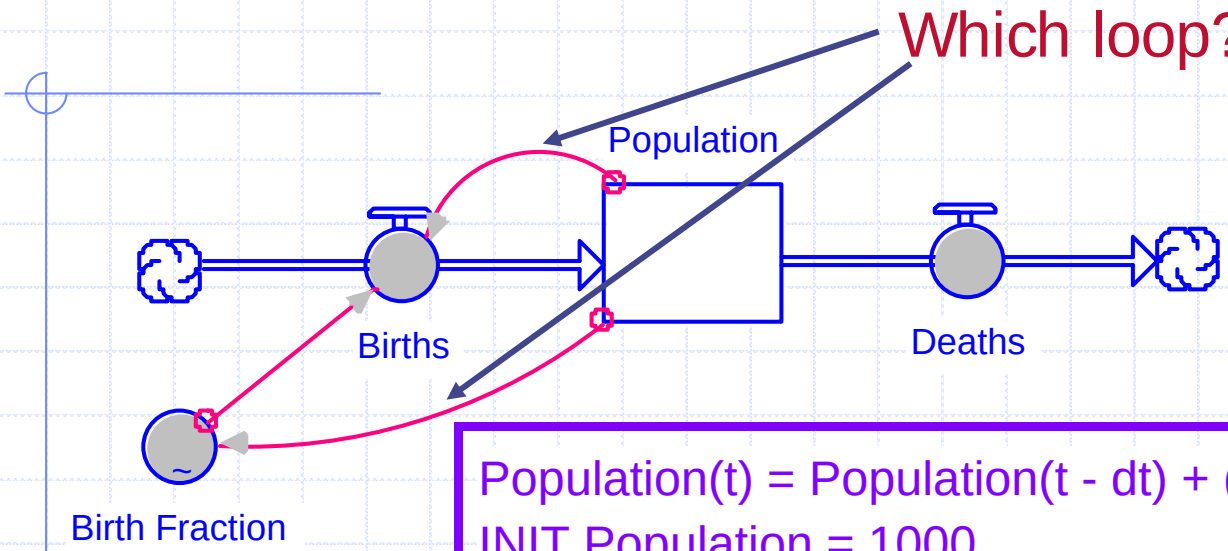
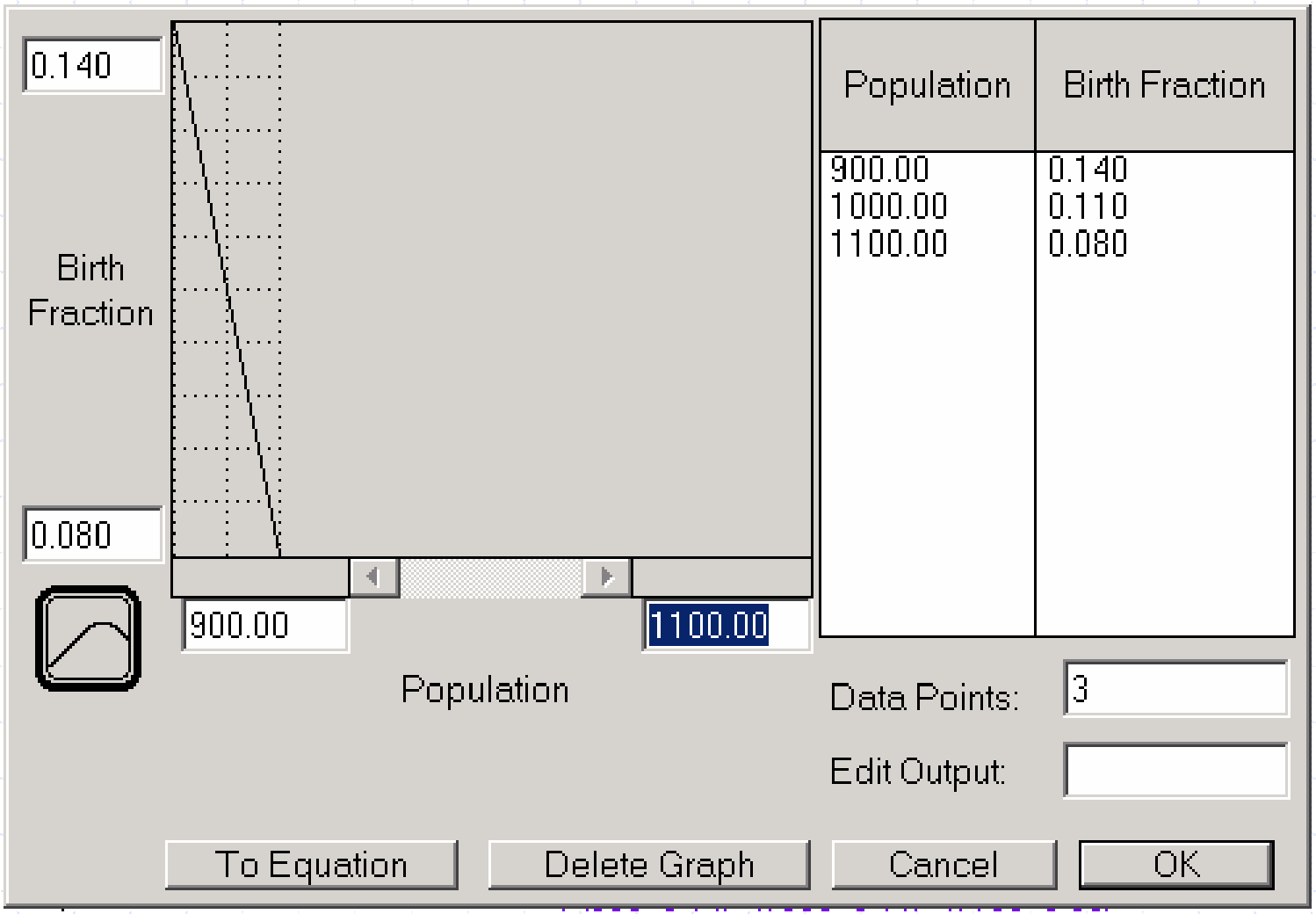


Table 1

Population(t) = Population(t - dt) + (Births - Deaths) * dt
INIT Population = 1000

INFLOWS:
Births = Birth_Fraction*Population
OUTFLOWS:
Deaths = 100
Birth_Fraction = GRAPH(Population)
(900, 0.14), (1000, 0.11), (1100, 0.08)

Birth Fraction Graph

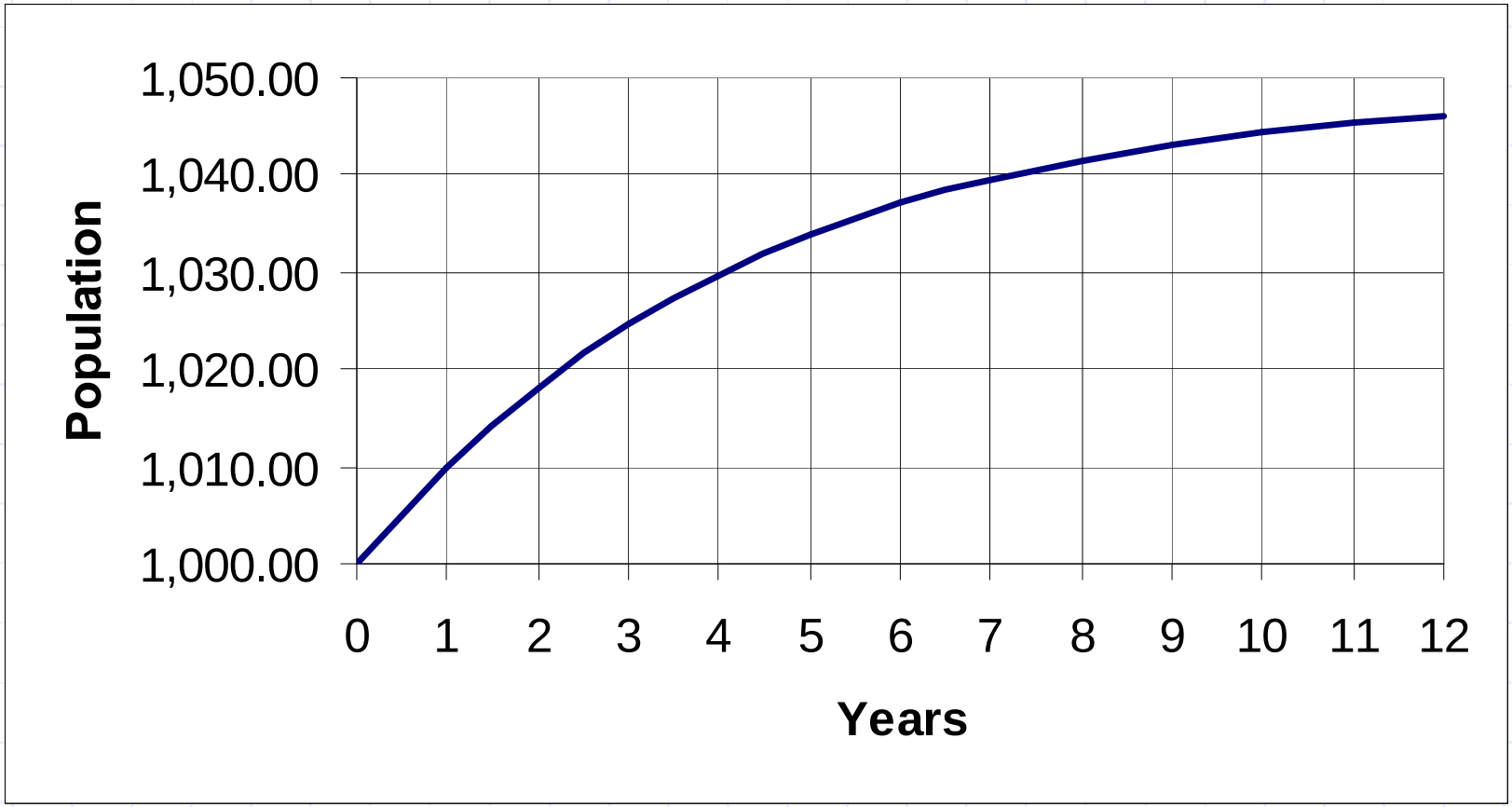


Population Table

- Population increases.
- All flows except Birth remain unchanged.
- Birth Fraction decreases.
- Birth inflow decreases.
- Population increases, but not as much.
- Counteracts increase.
- Thus, negative feedback.

Time	Birth Fraction	Population
0	0.110000	1,000.00
1	0.107000	1,010.00
2	0.104579	1,018.07
3	0.102638	1,024.54
4	0.101091	1,029.70
5	0.099863	1,033.79
6	0.098892	1,037.03
7	0.098126	1,039.58
8	0.097523	1,041.59
9	0.097049	1,043.17
10	0.096678	1,044.41
11	0.096386	1,045.38
Final	0.096158	1,046.14

Graph of Population



Description of Graph

- Increasing
- Increasing at a decreasing rate
  - Concave down
- Leveling off
  - approaching a horizontal asymptote
  - approaching a stable value

What will happen to the population if this continues?

Negative Feedback – Pop Decrease

Which loop?

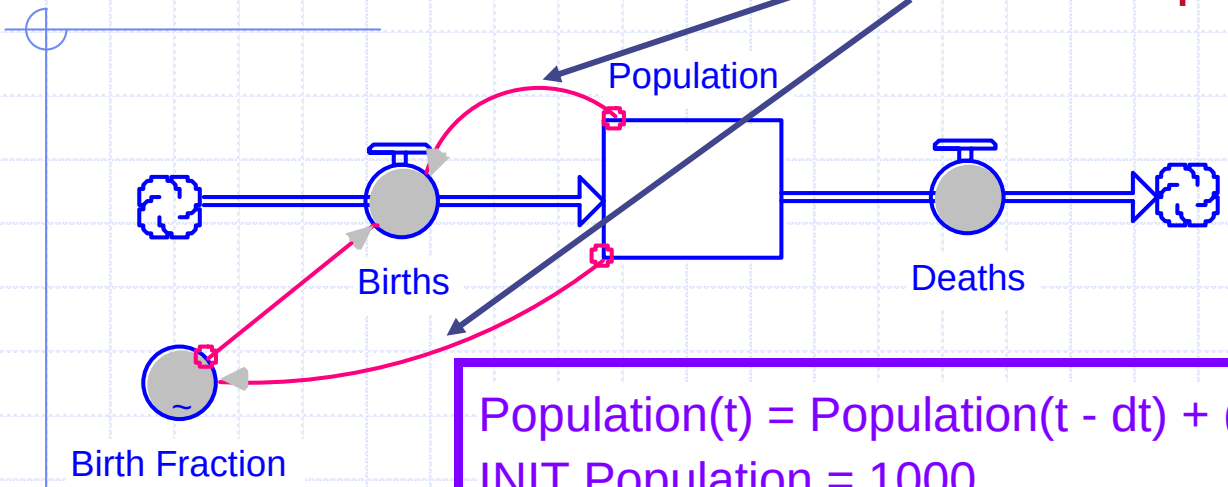


Table 1

Population(t) = Population(t - dt) + (Births - Deaths) * dt
INIT Population = 1000

INFLOWS:
Births = Birth_Fraction*Population
OUTFLOWS:
Deaths = 120
Birth_Fraction = GRAPH(Population)
(900, 0.14), (1000, 0.11), (1100, 0.08)

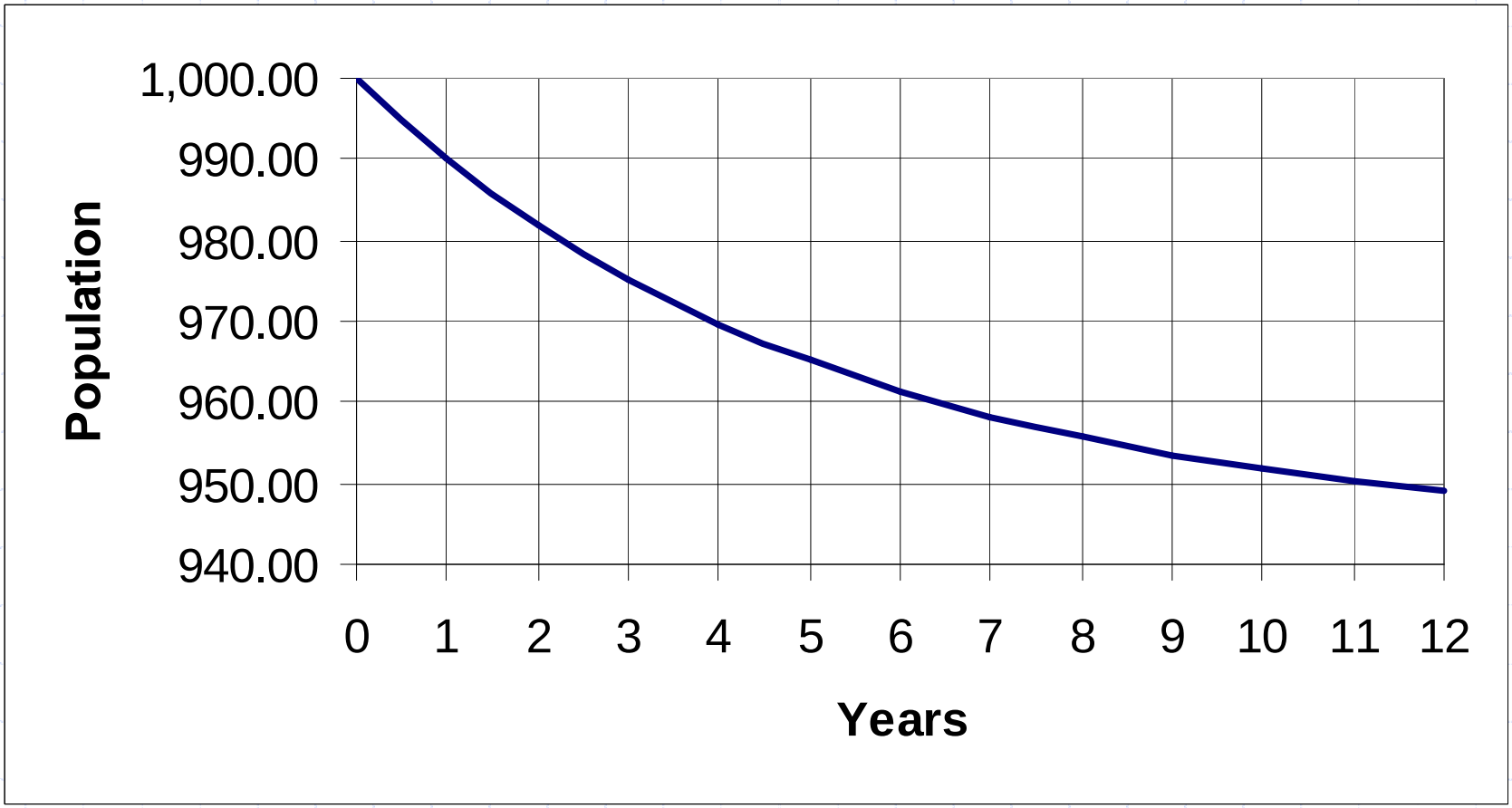
Note change

Population Table

- Population decreases.
- All flows except Birth remain unchanged.
- Birth Fraction increases.
- Birth inflow increases.
- Population decreases, but not as much.
- Counteracts decrease.
- Thus, negative feedback.

Time	Birth Fraction	Population
0	0.110000	1,000.00
1	0.113000	990.00
2	0.115439	981.87
3	0.117435	975.22
4	0.119078	969.74
5	0.120435	965.22
6	0.121562	961.46
7	0.122499	958.34
8	0.123280	955.73
9	0.123933	953.56
10	0.124480	951.73
11	0.124938	950.21
Final	0.125323	948.92

Graph of Population



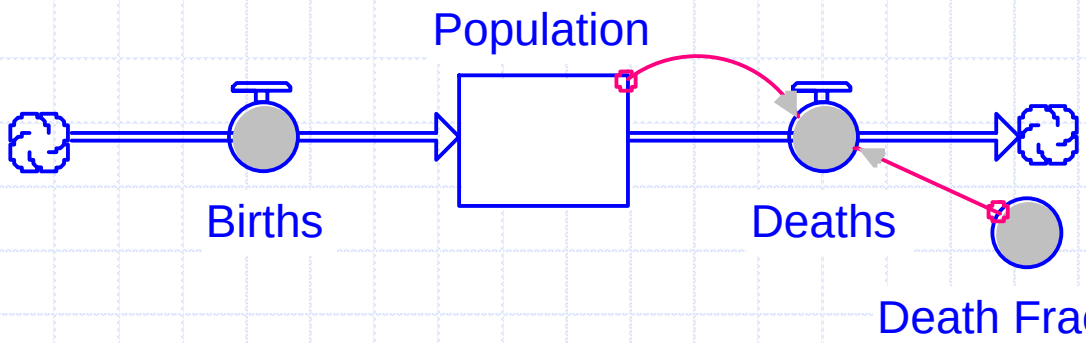
Description of Graph

- Decreasing
- Decreasing at a decreasing rate
  - Concave up
- Leveling off
  - Approaching a horizontal asymptote
  - Approaching a stable value

What will happen to the population if this continues?

To think about

- What happens if the loop(s) are on the outflow?



Graph 1

Population(t) = Population(t - dt) + (Births - Deaths) * dt
INIT Population = 1000 {persons}

INFLOWS:
Births = 100 {persons/year}
OUTFLOWS:
Deaths = Population*Death_Fraction {persons/year}
Death_Fraction = .11 {persons/person/year}