Section 9.6 Answer

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2. a. cooperation.
b. competition.

4. **a.** See Figure 1.
At $t = 0$, there are about 600 rabbits and 160 foxes. At $t = t_1$, the number of rabbits reacher a minimum of 80 and the number of foxes is 80. At $t = t_2$, the number of foxes reaches a minimum, 25, while the number of rabbits rebounds to 1000. At $t = t_3$, the number of foxes increases to 40 and the number of rabbit reaches a maximum of about 1750. The curves ends at $t = t_4$, the numbers of foxes and rabbits are 65 and 95, respectively.

b. Figure 2.

6. Figure 3.

8. **a.** solve $\frac{dA}{dt} = 0, \frac{dL}{dt} = 0$.
The we obtain $(A, L) = (0, 0)$ or $(5000, 200)$.

b.

$$\frac{dL}{dA} = \frac{dL/dt}{dA/dt} = frac{-}0.5L + 0.0001AL2A - 0.01AL.$$

c. Figure 4.
The solution curves are closed curves that have the equilibrium point $(5000, 200)$.

d. Figure 5. At $P_0(1000, 200)$, $dA/dt = 0$ and $dL/dt < 0$, so the number of ladybugs is decreasing. At P_0, there aren't enough aphids to support the ladybug population, so the number of ladybugs decreases and the number of aphids begins to increase. The ladybug population reaches a minimum at $P_1(5000, 100)$ while the aphid population increases in a dramatic way reaching its maximum at $P_2(14250, 200)$. Meanwhile, the ladybug population is increasing from P_1 to $P_3(5000, 355)$, and as we pass through P_2, the increasing number of ladybugs starts to delete the aphid population. At P_3, the ladybugs reach a maximum population, and start to decrease due to the reduced aphid population. Both populations then decrease until P_0, where the cycle starts over again.

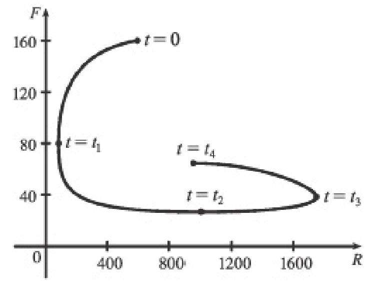

Figure 1:

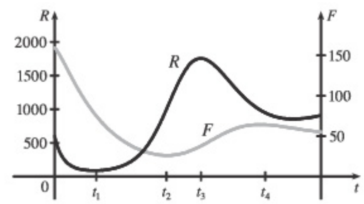

Figure 2:

e. Figure 6.

Both graphs have the same period and the graph of L peaks about a quarter of a cycle after the graph of A.

10. a. If $L = 0$, $A = 0$ or 10000. Since $dA/dt > 0$ for $0 < A < 10000$, the aphid population to increase to 10000 in the interval. Since $dA/dt < 0$ for $A > 10000$, the aphid population to decrease to 10000 in the interval. Hence, the aphid population to stabilize at 10000.

b. solve $\frac{dA}{dt} = 0, \frac{dL}{dt} = 0$.

The we obtain $(A, L) = (0, 0)$, $(10000, 0)$ or $(5000, 100)$.

c.

$$\frac{dL}{dA} = \frac{dL/dt}{dA/dt} = frac{-}0.5L + 0.0001AL2A(1 - 0.0001A) - 0.01AL.$$

d. Figure 7.

All of the phase trajectories spiral tightly around $(5000, 100)$.

e. Figure 8.

At $t = 0$, the bug population decreases rapidly and the aphid population decreases slightly before beginning to increase. As the aphid population continues to increase, the bug population reaches a minimum at about $(5000, 75)$. The gug population starts to increase

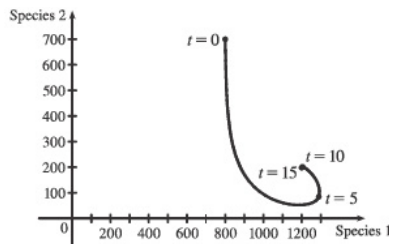

Figure 3:

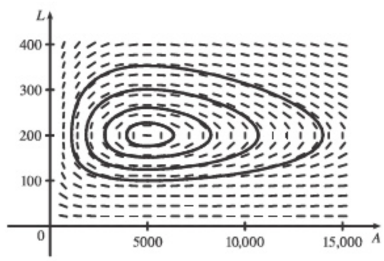

Figure 4:

and quickly stabilizes at 100, while the aphid population stabilizes at 5000.

f. Figure 9.

The graph of A peaks just after the graph of L has a minimum.

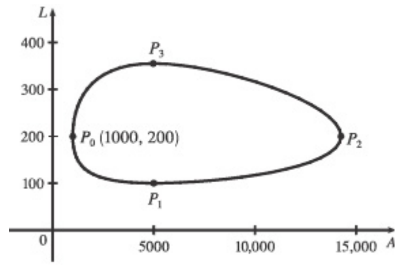

Figure 5:

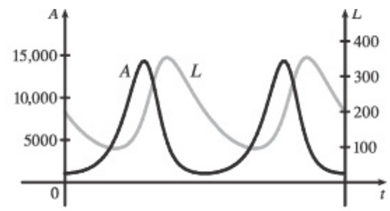

Figure 6:

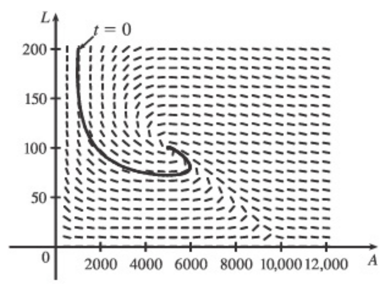

Figure 7:

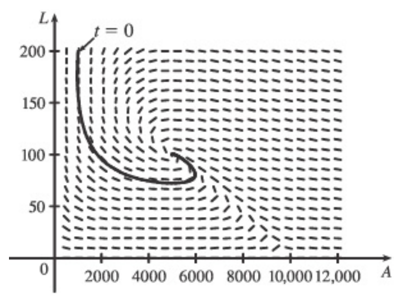

Figure 8:

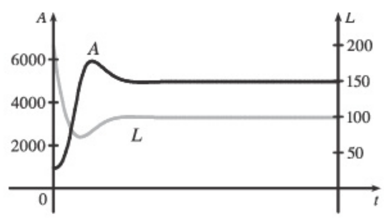

Figure 9: