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> #Please do NOT post Homework!
  #Jeton Hida, Assignment 9, October 4, 2021.
  read "/Users/jeton/Desktop/Math 336/M9.txt"
> #Question 1
> #i.
> f:=2*x*(1-x)
```

$$f := 2\,x\,(1-x) \quad \textbf{(1)}$$

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> Orb(f,x,.5,1000,2000)
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> SFP(f,x)
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[0.5000000000] **(3)**

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> #ii.
> f:=2.5*x*(1-x)
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$f := 2.5\, x\, (1 - x)$ **(4)**

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> Orb(f,x,.5,1000,2000)
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> SFP(f,x)
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$$[0.6000000000] \qquad (6)$$

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> #iii.
> f:=3.1*x*(1-x)
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$$f := 3.1\, x\, (1 - x) \qquad (7)$$

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> Orb(f,x,.5,1000,2000)
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> SFP(f,x)
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[ ] **(9)**

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> #iv.
> f:=(4+x)/(3+x)
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$$f := \frac{4+x}{3+x} \quad \textbf{(10)}$$

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> Orb(f,x,.5,1000,2000)
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> SFP(f,x)
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[1.236067977] **(12)**

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> #v.
> f:=(3+x)/(4+x)
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$$f := \frac{3+x}{4+x} \qquad (13)$$

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> Orb(f,x,.5,1000,2000)
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[0.7912878475, 0.7912878475, 0.7912878475, 0.7912878475, 0.7912878475, 0.7912878475, **(14)**
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> SFP(f,x)
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[0.791287848] **(15)**

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> #vi.
> f:=(3+x+x^2)/(4+x+2*x^2)
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$$f := \frac{x^2 + x + 3}{2\,x^2 + x + 4}$$ **(16)**

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> Orb(f,x,.5,1000,2000)
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```
> SFP(f,x)
```

$$[0.7351392587] \quad (18)$$

```
> #Question 2
solve(x=(x+a)/(x+b),x)
```

$$-\frac{b}{2}+\frac{1}{2}+\frac{\sqrt{b^2+4a-2b+1}}{2}, -\frac{b}{2}+\frac{1}{2}-\frac{\sqrt{b^2+4a-2b+1}}{2} \quad (19)$$

```
> diff((x+a)/(x+b),x)
```

$$\frac{1}{x+b}-\frac{x+a}{(x+b)^2} \quad (20)$$

```
> evalf(solve(x=1/(x + 2) - (x + 1)/(x + 2)^2,x))
```

$$0.205569431, -2.102784715+0.6654569515\,I, -2.102784715-0.6654569515\,I \quad (21)$$

```
> f:=1/(x + 2) - (x + 1)/(x + 2)^2
```

$$f := \frac{1}{x+2} - \frac{x+1}{(x+2)^2} \quad \textbf{(22)}$$

```
> FP(f,x);
  SFP(f,x)
```

$[0.205569431, -2.102784715 + 0.6654569515\ \mathrm{I}, -2.102784715 - 0.6654569515\ \mathrm{I}]$

$[0.205569431]$ **(23)**

```
> Orb(f,x,.5,1000,1010);
  evalf(solve(x=1/(x + 3) - (x + 2)/(x + 3)^2,x))
```

[0.2055694305, 0.2055694305, 0.2055694305, 0.2055694305, 0.2055694305, 0.2055694305, 0.2055694305, 0.2055694305, 0.2055694305, 0.2055694305, 0.2055694305, 0.2055694305]

$0.103803402, -3.051901701 + 0.5652358515\ \mathrm{I}, -3.051901701 - 0.5652358515\ \mathrm{I}$ **(24)**

```
> f:=1/(x + 3) - (x + 2)/(x + 3)^2
```

$$f := \frac{1}{3+x} - \frac{x+2}{(3+x)^2} \quad \textbf{(25)}$$

```
> SFP(f,x)
```

$[0.103803402]$ **(26)**

```
> Orb(f,x,.5,1000,1010)
```

[0.1038034027, 0.1038034027, 0.1038034027, 0.1038034027, 0.1038034027, 0.1038034027, 0.1038034027, 0.1038034027, 0.1038034027, 0.1038034027, 0.1038034027, 0.1038034027] **(27)**

```
> FP(f,x)
```

$[0.103803402, -3.051901701 + 0.5652358515\ \mathrm{I}, -3.051901701 - 0.5652358515\ \mathrm{I}]$ **(28)**

```
> evalf(solve(x=1/(x + 17) - (x + 12)/(x + 17)^2,x))
```

$0.01726595, -17.00863297 + 0.5419821975\ \mathrm{I}, -17.00863297 - 0.5419821975\ \mathrm{I}$ **(29)**

```
> f:=1/(x + 17) - (x + 12)/(x + 17)^2
```

$$f := \frac{1}{x+17} - \frac{x+12}{(x+17)^2} \quad \textbf{(30)}$$

```
> FP(f,x);
  SFP(f,x);
  Orb(f,x,.5,1000,1010)
```

$[0.01726595, -17.00863297 + 0.5419821975\ \mathrm{I}, -17.00863297 - 0.5419821975\ \mathrm{I}]$

$[0.01726595]$

[0.01726594814, 0.01726594814, 0.01726594814, 0.01726594814, 0.01726594814, 0.01726594814, 0.01726594814, 0.01726594814, 0.01726594814, 0.01726594814, 0.01726594814, 0.01726594814] **(31)**

```
> #Question 3
> #Arbitrary k between 1 and 4 (f(x)=k*x*(1-x)), will evaluate with
  different values of k and show how x=0 is never stable but other
  value is sometimes stable
> f:=1.1*x*(1-x)
```

$$f := 1.1\, x\, (1 - x) \quad \textbf{(32)}$$

```
> FP(f,x)
```
$$[0., 0.09090909091] \quad (33)$$

```
> SFP(f,x)
```
$$[0.09090909091] \quad (34)$$

```
> a:=proc(n) option remember:
  if n=0 then .001:
  else 1.1*a(n-1)*(1-a(n-1)):
  fi:
  end:
> seq(a(n),n=1000..1010)
```
0.09090909087, 0.09090909087, 0.09090909087, 0.09090909087, 0.09090909087, 0.09090909087, 0.09090909087, 0.09090909087, 0.09090909087, 0.09090909087, 0.09090909087 (35)

```
> f:=2*x*(1-x)
```
$$f := 2\,x\,(1-x) \quad (36)$$

```
> FP(f,x)
```
$$[0., 0.5000000000] \quad (37)$$

```
> SFP(f,x)
```
$$[0.5000000000] \quad (38)$$

```
> a:=proc(n) option remember:
  if n=0 then .001:
  else 2*a(n-1)*(1-a(n-1)):
  fi:
  end:
> seq(a(n),n=1000..1010)
```
0.5000000000, 0.5000000000, 0.5000000000, 0.5000000000, 0.5000000000, 0.5000000000, 0.5000000000, 0.5000000000, 0.5000000000, 0.5000000000, 0.5000000000 (39)

```
> f:=2.9*x*(1-x)
```
$$f := 2.9\,x\,(1-x) \quad (40)$$

```
> FP(f,x)
```
$$[0., 0.6551724138] \quad (41)$$

```
> SFP(f,x)
```
$$[0.6551724138] \quad (42)$$

```
> a:=proc(n) option remember:
  if n=0 then .001:
  else 2.9*a(n-1)*(1-a(n-1)):
  fi:
  end:
> seq(a(n),n=1000..1010)
```
0.6551724133, 0.6551724144, 0.6551724133, 0.6551724144, 0.6551724133, 0.6551724144, 0.6551724133, 0.6551724144, 0.6551724133, 0.6551724144, 0.6551724133 (43)

```
> f:=3.1*x*(1-x)
```
$$f := 3.1\,x\,(1-x) \quad (44)$$

```
> FP(f,x)
```
$$[0., 0.6774193548] \quad (45)$$

```
> SFP(f,x)
```
$$[\ ] \quad (46)$$

```
> a:=proc(n) option remember:
  if n=0 then .001:
  else 3.1*a(n-1)*(1-a(n-1)):
  fi:
  end:
> seq(a(n),n=1000..1010)
```

0.5580141256, 0.7645665197, 0.5580141256, 0.7645665197, 0.5580141256, 0.7645665197, 0.5580141256, 0.7645665197, 0.5580141256, 0.7645665197, 0.5580141256 **(47)**

```
> #You'll see that with the programs ran above, 0 is never stable. As
  long as population does not start at 0 it will never go to 0 with
  this model. Other fixed point is stable only when k=1 to 2.9. At 3
  we lose stability in the point, and at k=3.1 we appear to have a
  bifurcation value as the population has a period of 2 where it
  jumps back and forth between two values for each step.
```

```
> #Question 4
  f:=k*x*(1-x)
```

$$f := k\,x\,(1-x) \qquad \textbf{(48)}$$

```
> Comp(f,x)
```

$$-k^2\,x\,(-1+x)\,\left(k\,x^2-k\,x+1\right) \qquad \textbf{(49)}$$

```
> solve(x=%,x)
```

$$0,\ \frac{k-1}{k},\ \frac{\frac{k}{2}+\frac{1}{2}+\frac{\sqrt{k^2-2\,k-3}}{2}}{k},\ \frac{\frac{k}{2}+\frac{1}{2}-\frac{\sqrt{k^2-2\,k-3}}{2}}{k} \qquad \textbf{(50)}$$

```
> f:=-3.2^2*x*(-1 + x)*(3.2*x^2 - 3.2*x + 1)
```

$$f := -10.24\,x\,(-1+x)\,\left(3.2\,x^2-3.2\,x+1\right) \qquad \textbf{(51)}$$

```
> FP(f,x)
```

[0., 0.6875000000, 0.5130445095, 0.7994554905] **(52)**

```
> SFP(f,x)
```

[0.5130445095, 0.7994554905] **(53)**

```
> f:=-1^2*x*(-1 + x)*(1*x^2 - 1*x + 1)
```

$$f := -x\,(-1+x)\,\left(x^2-x+1\right) \qquad \textbf{(54)}$$

```
> FP(f,x)
```

[0., 0., 1. + I, 1. − I] **(55)**

```
> SFP(f,x)
```

[ ] **(56)**

```
> f:=-2.9^2*x*(-1 + x)*(2.9*x^2 - 2.9*x + 1);
  FP(f,x);
  SFP(f,x);
```

$$f := -8.41\,x\,(-1+x)\,\left(2.9\,x^2-2.9\,x+1\right)$$

[0., 0.6551724138, 0.6724137931 − 0.1076723793 I, 0.6724137931 + 0.1076723793 I]

[0.6551724138] **(57)**

```
> f:=-3.1^2*x*(-1 + x)*(3.1*x^2 -3.1*x + 1);
  FP(f,x);
  SFP(f,x);
```

$$f := -9.61\,x\,(-1+x)\,\left(3.1\,x^2-3.1\,x+1\right)$$

[0., 0.6774193548, 0.5580141252, 0.7645665200]

$$[0.5580141252, 0.7645665200] \quad (58)$$

```
> f:=-3.45^2*x*(-1 + x)*(3.45*x^2 -3.45*x + 1);
  FP(f,x);
  SFP(f,x);
```

$$f := -11.9025\, x\, (-1 + x)\, \left(3.45\, x^2 - 3.45\, x + 1\right)$$

$$[0., 0.7101449275, 0.4398409899, 0.8500140826]$$

$$[\ ] \quad (59)$$

```
> f:=3.45*x*(1-x)
```

$$f := 3.45\, x\, (1 - x) \quad (60)$$

```
> Orb(f,x,.5,1000,1010)
```

[0.4462251607, 0.8525235201, 0.4337587289, 0.8473617243, 0.4462224221, 0.8525225037, 0.4337612012, 0.8473628542, 0.4462197139, 0.8525214988, 0.4337636455, 0.8473639713] **(61)**

```
> #We have two stable points when k is between 3.1 and 3.5. When k=
  3.5 we go from a period of 2 to a period of 4
```