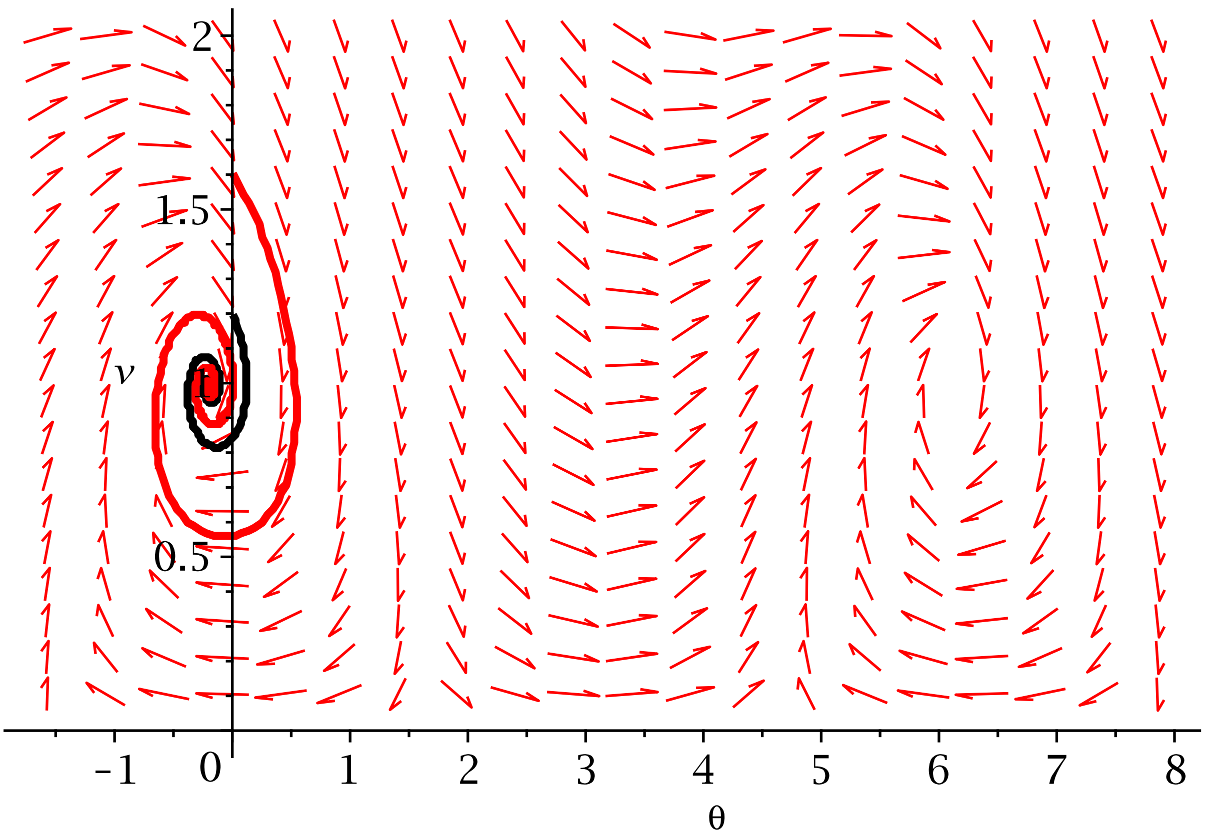
2019-10-17

```
> R :='R':
phug := [ D(theta)(t) = v(t) - cos(theta(t))/v(t), D(v)(t) =-sin(theta(t)) - R·v(t)^2 ]:
xphug := [ op(phug), D(x)(t) = v(t)·cos(t), D(y)(t) = v(t)·sin(t) ]:
```

```
> with(DEtools) :
```

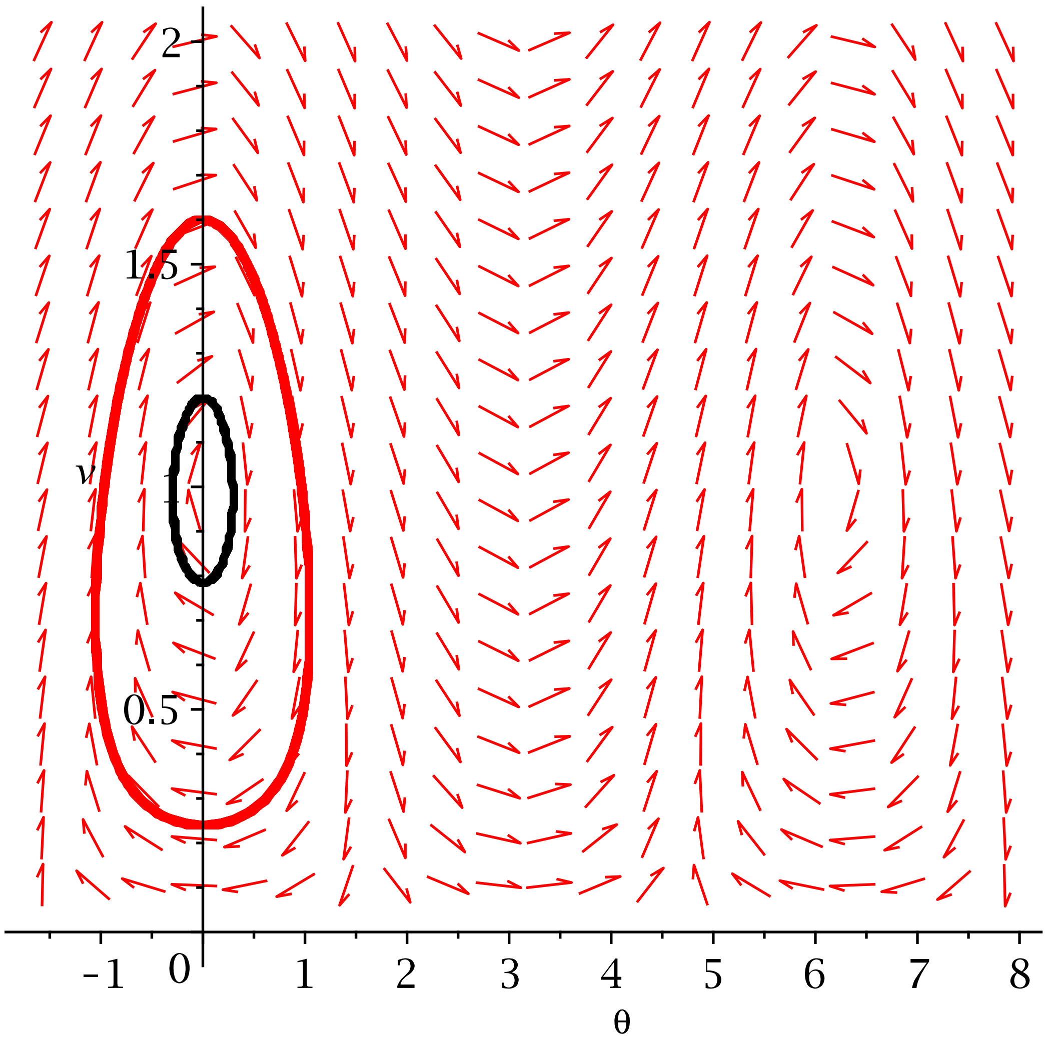
```
> R := .2;
DEplot( phug, [theta, v], t = 0..100, [[v(0) = 1.2, theta(0) = 0], [v(0) = 1.6,
    theta(0) = 0]], theta = - Pi/2 .. 5·Pi/2, v = 0..2, linecolor = [black, red], color = red,
    stepsize = .05)
```

$$R := 0.2$$



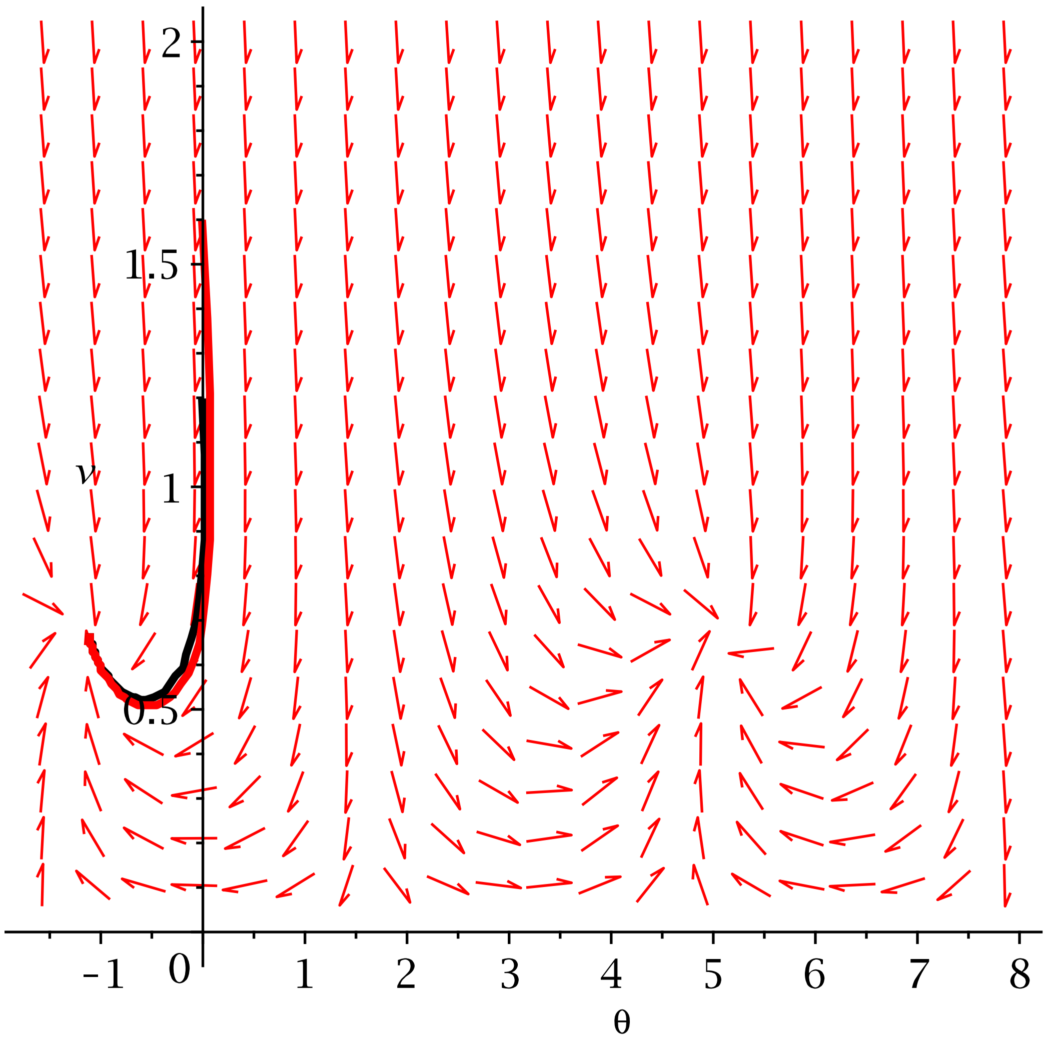

```
> R := 0;
DEplot( phug, [theta, v], t = 0..100, [[v(0) = 1.2, theta(0) = 0], [v(0) = 1.6,
    theta(0) = 0]], theta = - Pi/2 .. 5·Pi/2, v = 0..2, linecolor = [black, red], color = red,
    stepsize = .05)
```

$R := 0$



> $R := 2;$
>
> $DEplot\left(phug, [\text{theta}, v], t = 0..100, [[v(0) = 1.2, \text{theta}(0) = 0], [v(0) = 1.6, \text{theta}(0) = 0]], \text{theta} = -\frac{\text{Pi}}{2}..\frac{5 \cdot \text{Pi}}{2}, v = 0..2, linecolor = [black, red], color = red, stepsize = .05\right)$

$R := 2$



At this point, there was a lot of discussion at the board about linearizing a differential equation at a fixed point and the possibilities for what we can see. I won't reproduce it here, since it is all in Section 6 (pages 3:13-3:16) of the class notes on the phugoid system.

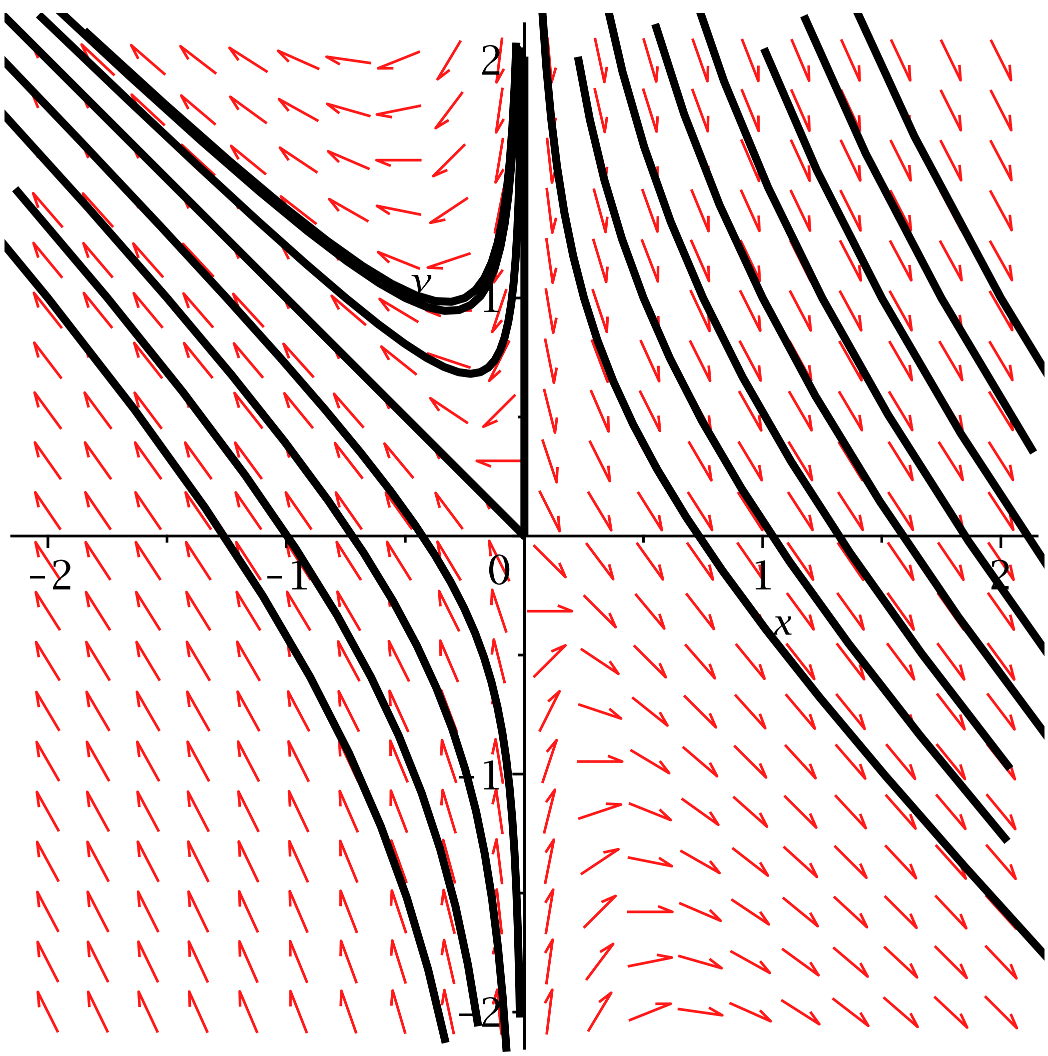
> $linsys := [D(x)(t) = a \cdot x(t) + b \cdot y(t), D(y)(t) = c \cdot x(t) + d \cdot y(t)]$

$$linsys := [D(x)(t) = a\,x(t) + b\,y(t), D(y)(t) = c\,x(t) + d\,y(t)] \quad (1)$$

> $first := eval(linsys, \{a = 2, b = 0, c = -3, d = -1\})$

$$first := [D(x)(t) = 2\,x(t), D(y)(t) = -3\,x(t) - y(t)] \quad (2)$$

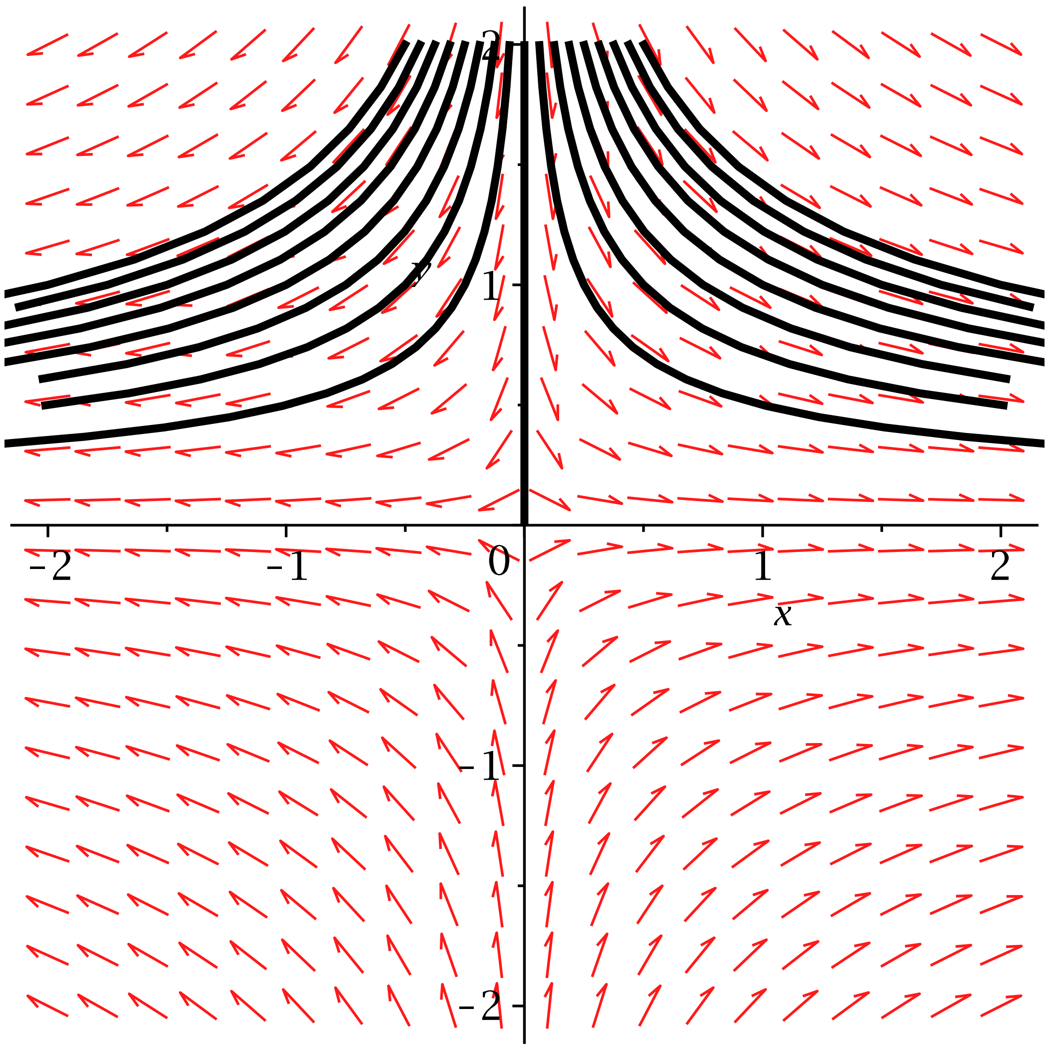
> $DEplot(first, [x, y], t = -10..10, [seq([x(0) = i, y(0) = 1], i = -2..2, .25),], x = -2..2, y = -2..2, linecolor = black, stepsize = 0.1)$



> *first0* := *eval*(*linsys*, {*a* = 2, *b* = 0, *c* = 0, *d* = -1})

$$first0 := [D(x)(t) = 2\,x(t),\ D(y)(t) = -y(t)] \qquad \textbf{(3)}$$

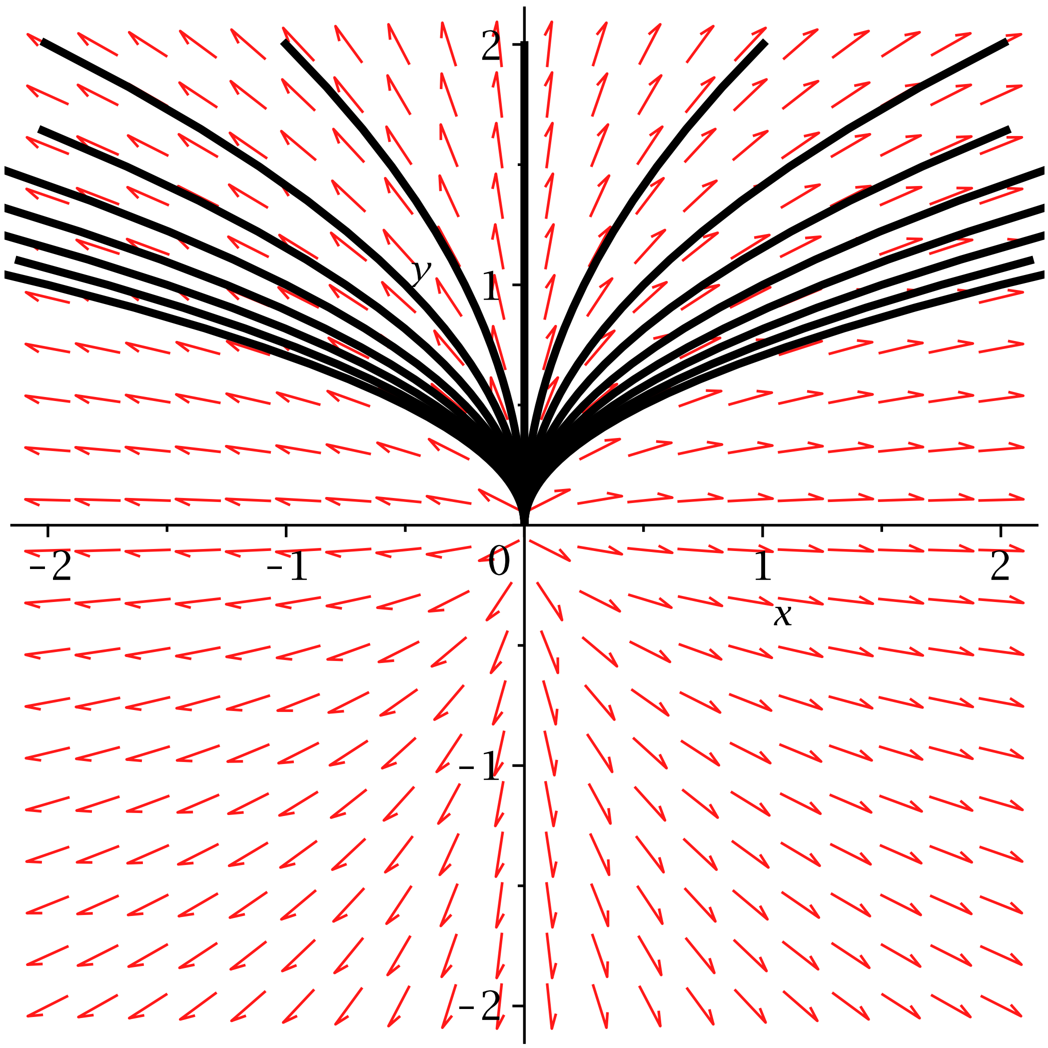
> *DEplot*(*first0*, [*x*, *y*], *t* = -10 ..10, [*seq*([*x*(0) = *i*, *y*(0) = 1], *i* = -2 .. 2, .25),], *x* = -2 ..2, *y* = -2 ..2, *linecolor* = *black*, *stepsize* = 0.1)



> $first2 := eval(linsys, \{a = 2, b = 0, c = 0, d = +1\})$

$$first2 := [\mathrm{D}(x)(t) = 2\,x(t),\ \mathrm{D}(y)(t) = y(t)] \quad \textbf{(4)}$$

> $DEplot(first2, [x, y], t = -10..10, [seq([x(0) = i, y(0) = 1], i = -2..2, .25),], x = -2..2, y = -2..2, linecolor = black, stepsize = 0.1)$



Lots more talky talk   Read the notes.