> theta

θ **(1)**

>

Want to describe an (unpowered) glider.
Coords which describe (almost) everything: θ = angle nose makes with horizontal.
v = forward velocity, ie, in the direction of θ

Restrict to v>0, $\theta = any$

Not describing in x-y coordinates,

Can write equations as

$$\frac{dv}{dt} = -\sin(\theta) - Rv^2 \qquad \frac{d\theta}{dt} = v - \frac{\cos\theta}{v}$$

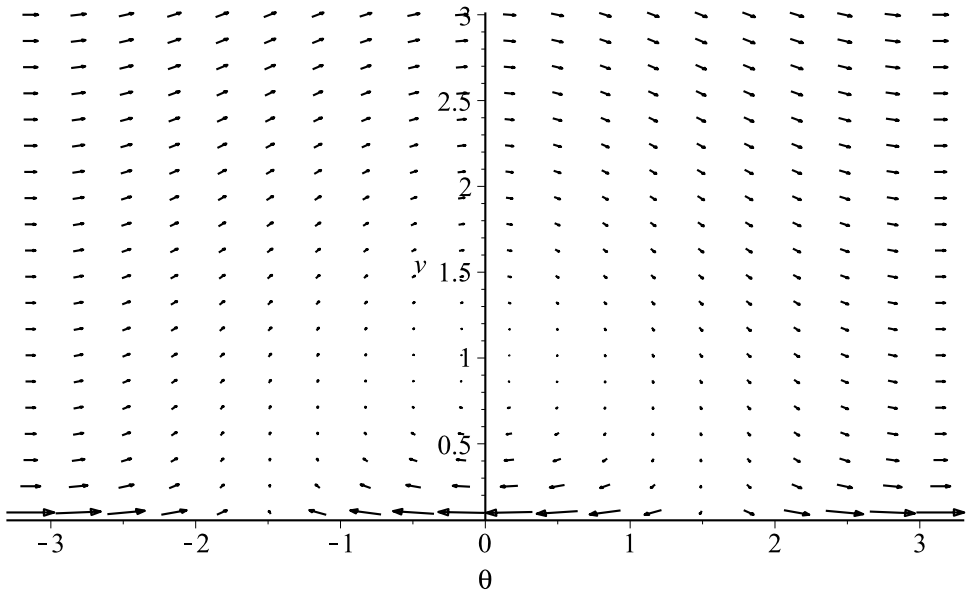
Remember that v and θ are functions of t, ie $\theta(t), v(t)$
Easy case: R=0.

special solution, $\theta(t) = 0, v(t) = 1$ --- *level flight*

What happens if $\theta = 0$, *but* $v(t) > 1$ (**by** *a little*),
initially, v will decrease, θ *increase*, *but* **then** *v increases*, θ *decrease*, *sinusoidal motion*,.

> *with*(*plots*) :

> *fieldplot*$\left(\left[v - \frac{\cos(\text{theta})}{v}, \ -\sin(\text{theta}) \right], \ \text{theta} = -\text{Pi}..\text{Pi}, v = 0.1..3, arrows = slim \right)$;



Use the DEtools package, use DEplot

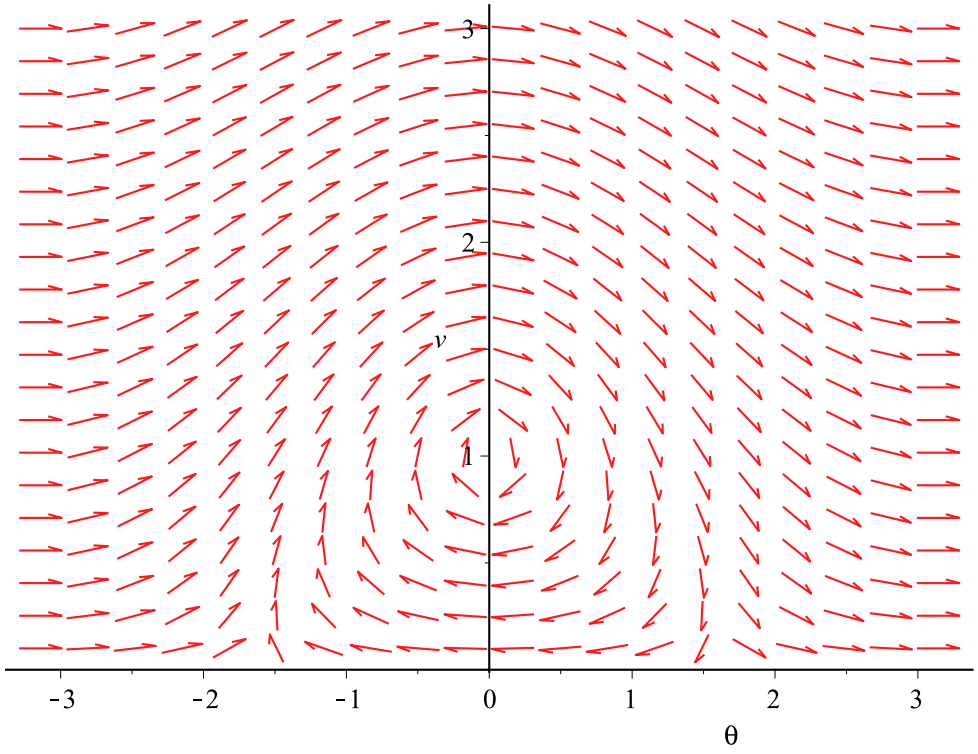
```
> restart;
> with(DEtools) :
> phug := [diff(theta(t), t) = v(t) - cos(theta(t))/v(t), diff(v(t), t) = -sin(theta(t)) - R·(v(t))^2];
```

$$phug := \left[\frac{d}{dt}\,\theta(t) = v(t) - \frac{\cos(\theta(t))}{v(t)},\ \frac{d}{dt}\,v(t) = -\sin(\theta(t))\right] \quad (2)$$

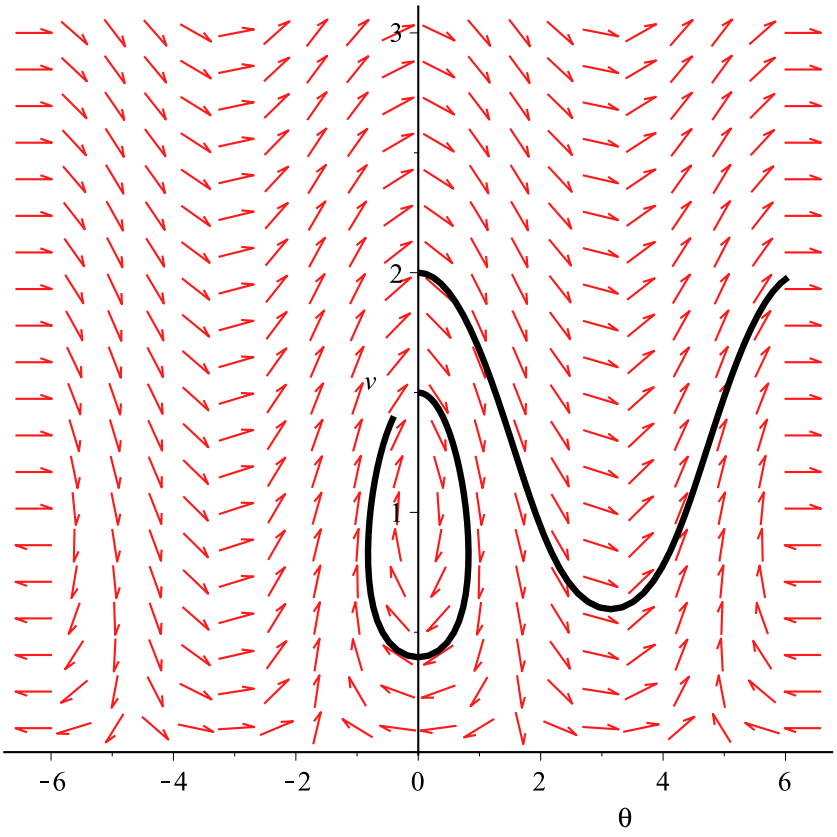
```
> R := 0;
```

$$R := 0 \quad (3)$$

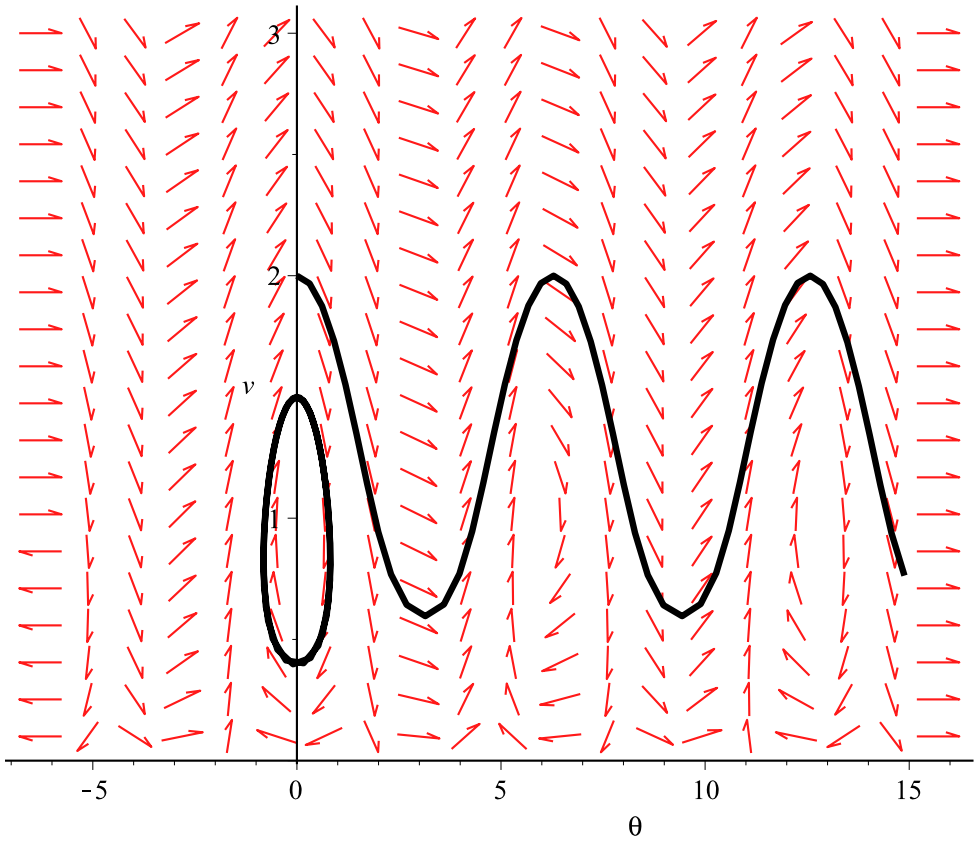
```
> DEplot( phug, [theta(t), v(t)], t = 0..1, theta = -Pi..Pi, v = 0.1..3);
```



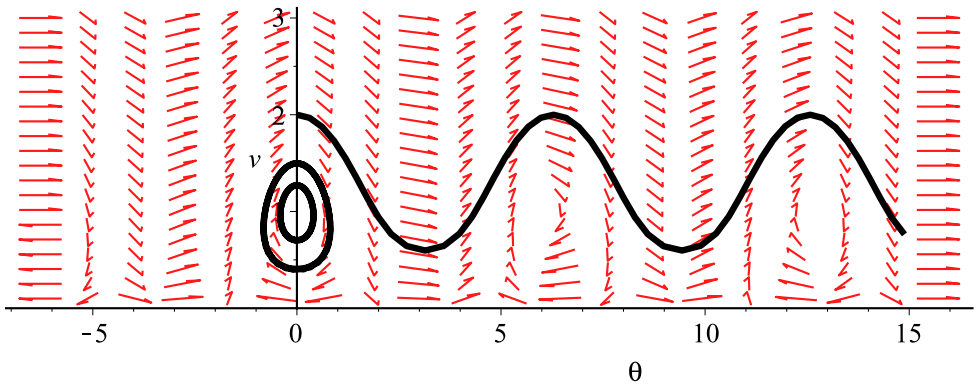

```
> DEplot( phug, [theta(t), v(t)], t = 0..4, theta = -2·Pi..2·Pi, v = 0.1..3,
      [[theta(0) = 0, v(0) = 1.5], [theta(0) = 0, v(0) = 2]], linecolor = black);
```



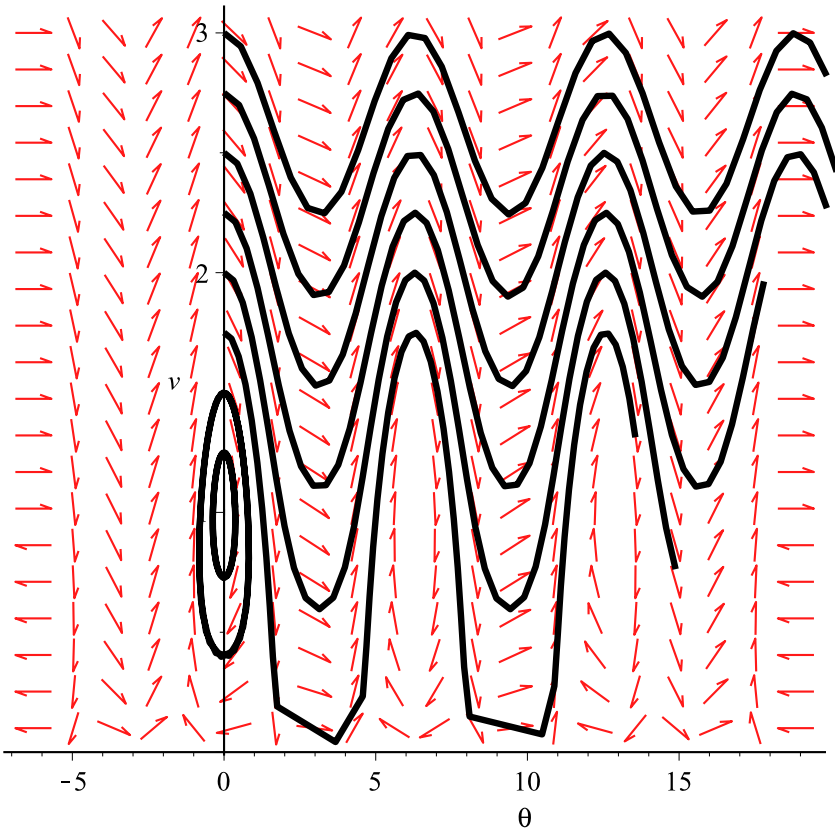

```
> DEplot( phug, [theta(t), v(t)], t = 0..10, theta = -2·Pi..5·Pi, v = 0.1..3,
      [[theta(0) = 0, v(0) = 1.5], [theta(0) = 0, v(0) = 2]], linecolor = black);
```



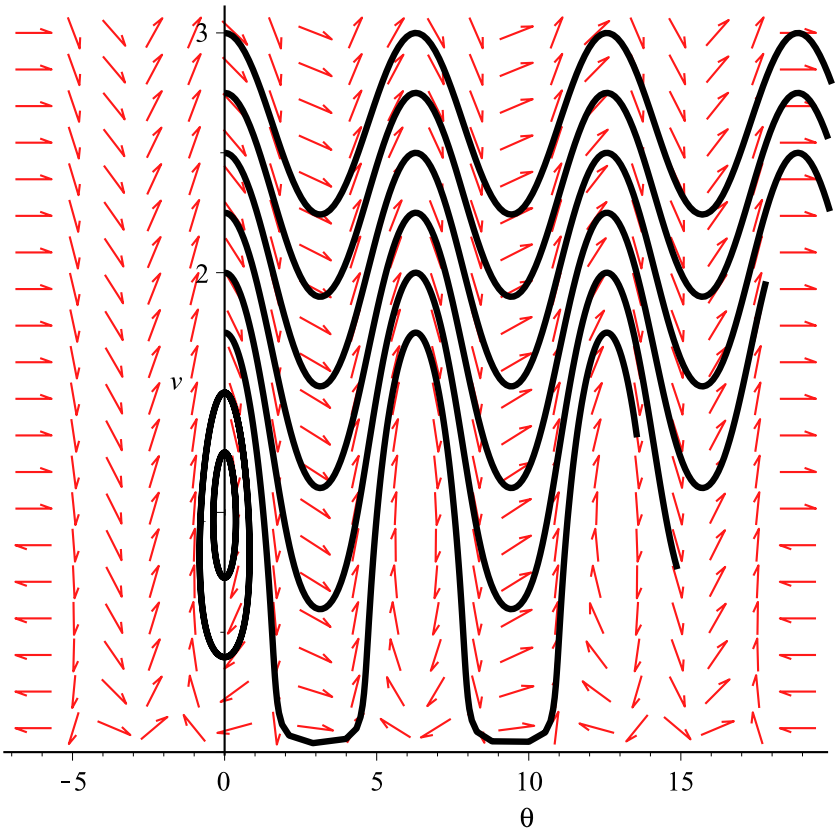

```
> DEplot( phug, [theta(t), v(t)], t = 0..10, theta = -2·Pi..5·Pi, v = 0.1..3,
      [[theta(0) = 0, v(0) = 0.7], [theta(0) = 0, v(0) = 1.5], [theta(0) = 0, v(0) = 2]],
  linecolor = black);
```



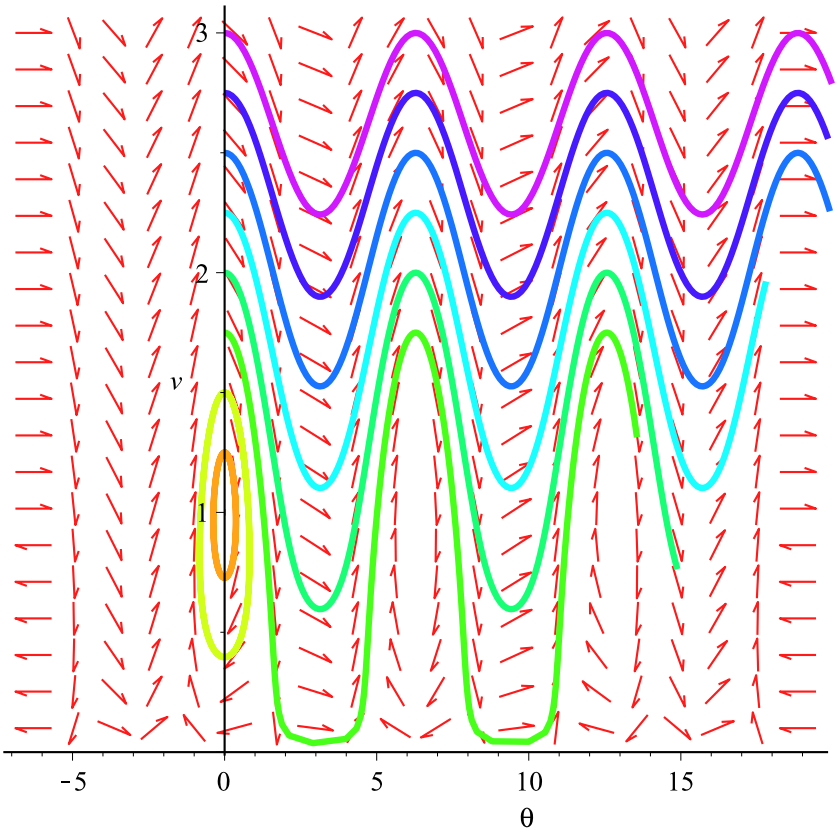

```
> DEplot( phug, [theta(t), v(t)], t = 0..10, theta = -2·Pi..6·Pi, v = 0.1..3,
      [seq( [theta(0) = 0, v(0) = i], i = 1 .. 3, 0.25)], linecolor = black, obsrange = false);
```




```
> DEplot( phug, [theta(t), v(t)], t = 0..10, theta = -2·Pi..6·Pi, v = 0.1..3,
      [seq([theta(0) = 0, v(0) = i], i = 1 .. 3, 0.25)], linecolor = black, obsrange = false,
  numpoints = 200);
```




```
> DEplot( phug, [theta(t), v(t)], t = 0..10, theta = -2·Pi..6·Pi, v = 0.1..3,
      [seq([theta(0) = 0, v(0) = i], i = 1.. 3, 0.25)], linecolor = [seq(COLOR(HUE, i), i = 0
  ..1, 0.1)], obsrange = false, numpoints = 200);
```


3
2
1
v
-5
0
5
10
15
θ