ECE 331 - Homework #12

DC Series-Shunt & Series Motors - Due Monday, May 5th, 4PM

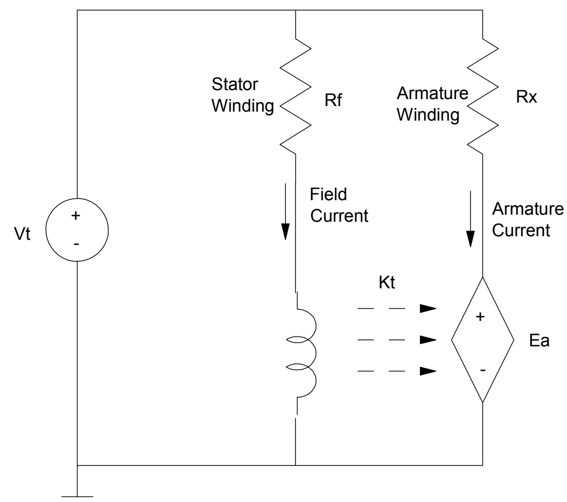
Problem 1-3) Assume a DC Series motor. Let Vt = 120VDC, Rf = 150 Ohms, **Rx= 0.3 Ohm**, Nf1= 30, Na = 30, and a reluctance of 1000.

The torque constant is related to the current If:

$$I_f = \frac{120V}{150\Omega} = 0.8A$$

$$\Phi_P = \frac{N_f I_f}{Rel} = \left(\frac{(30)(0.8A)}{1000}\right) = 0.024Wb$$

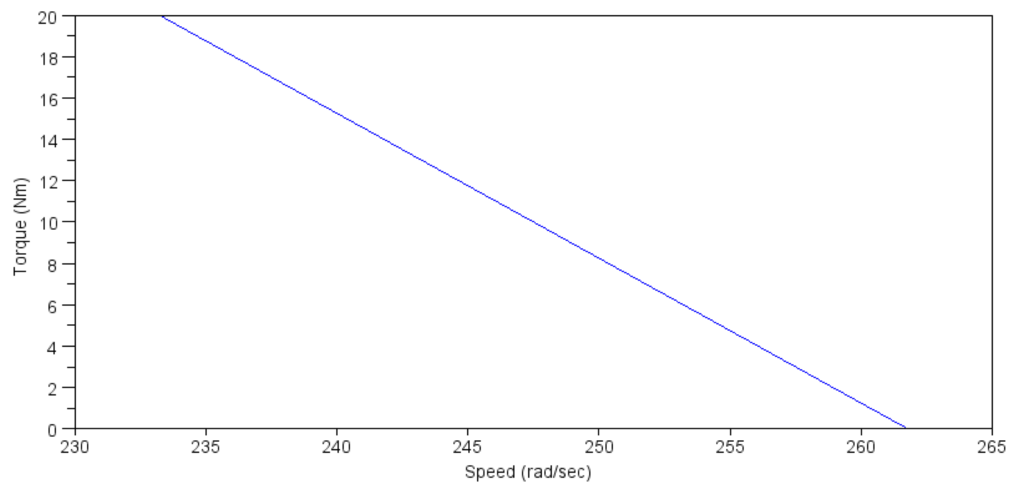
$$K_t = \frac{2N_a\Phi_P}{\pi} = 0.4584\ \frac{Nm}{A}$$



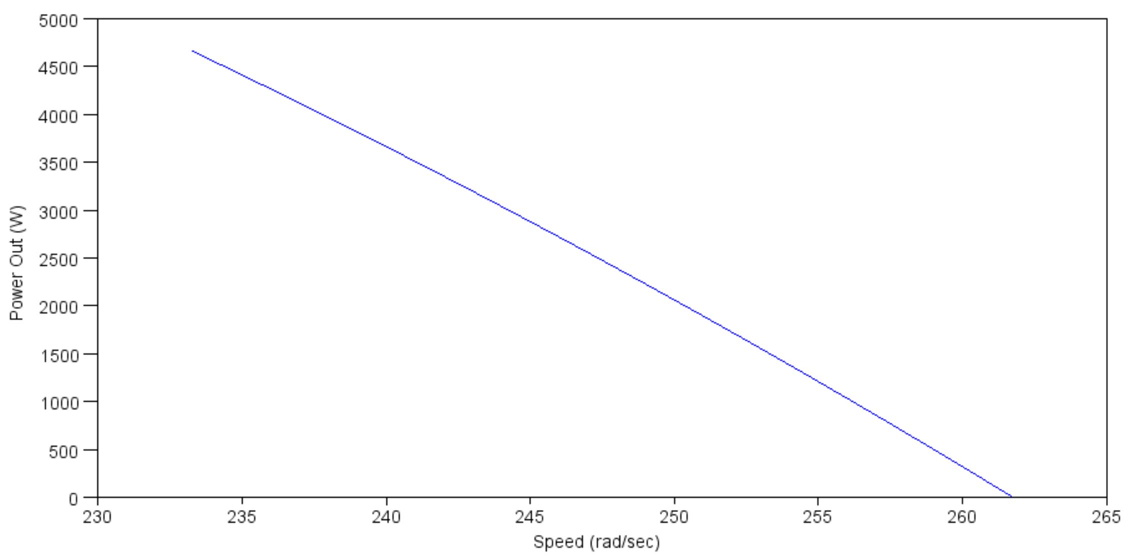
1) For this motor, assume the load varies from 0 to 20Nm. Compute and plot:

- speed vs. load
- speed vs. power
- power vs. efficiency

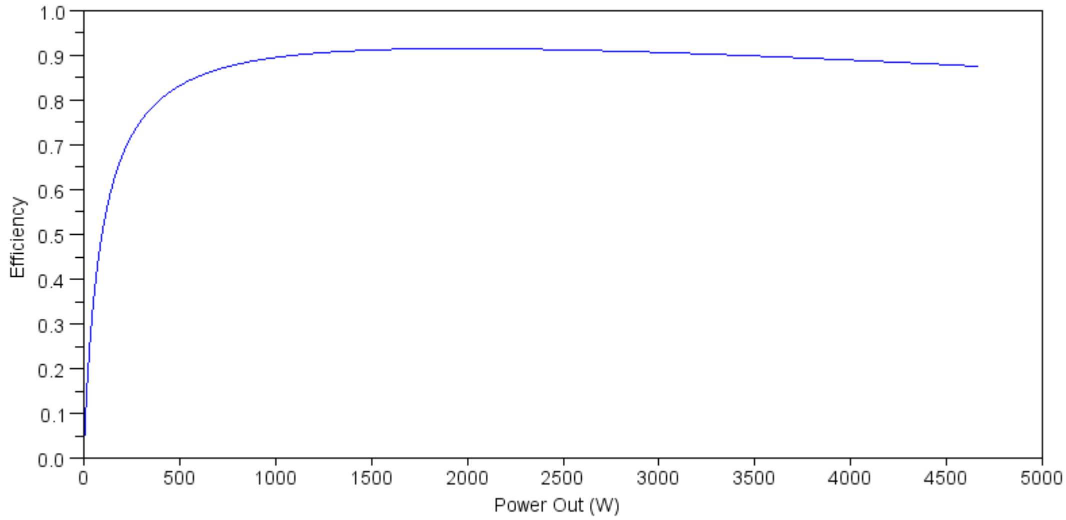
```
SciLab Code:
Kt = 0.4584;
Rx = 0.3;
Vt = 120;

T = [0:0.01:20]';

Ia = T / Kt;
Ea = Vt - Ia*Rx;
w = Ea / Kt;

Po = Ia .* Ea;

If = 120 / 150;

Pin = (Ia + If) * Vt;

eff = Po ./ Pin;

plot(w,T);
xlabel('Speed (rad/sec)');
ylabel('Torque (Nm)');

plot(w,Po);
xlabel('Speed (rad/sec)');
ylabel('Power Out (W)');

plot(Po, eff);
xlabel('Power Out (W)');
ylabel('Efficiency')
```



Speed vs. Torque. As the load increases, the speed drops (proportionaly)

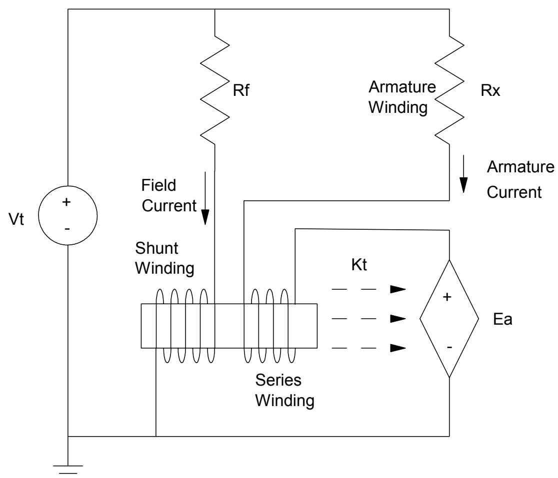


Speed vs. Power: Part of a parabola which has a peak at 1/2 of the no-load speed



Power vs. Efficiency: Peak efficiancy is around 2000W at around 90%

2a) Assume the motor from problem #1 is modified into a series-shunt motor with field weakening so that



$$K_t = \left(0.4584 - \frac{I_a}{1000}\right) \frac{Nm}{A}$$

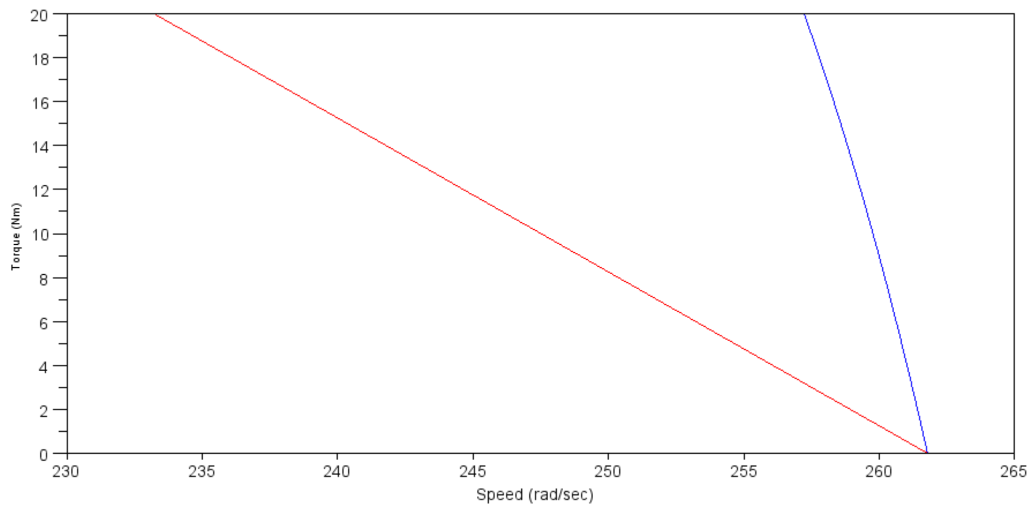
Compute and plot:

- speed vs. load
- speed vs. power
- power vs. efficiency

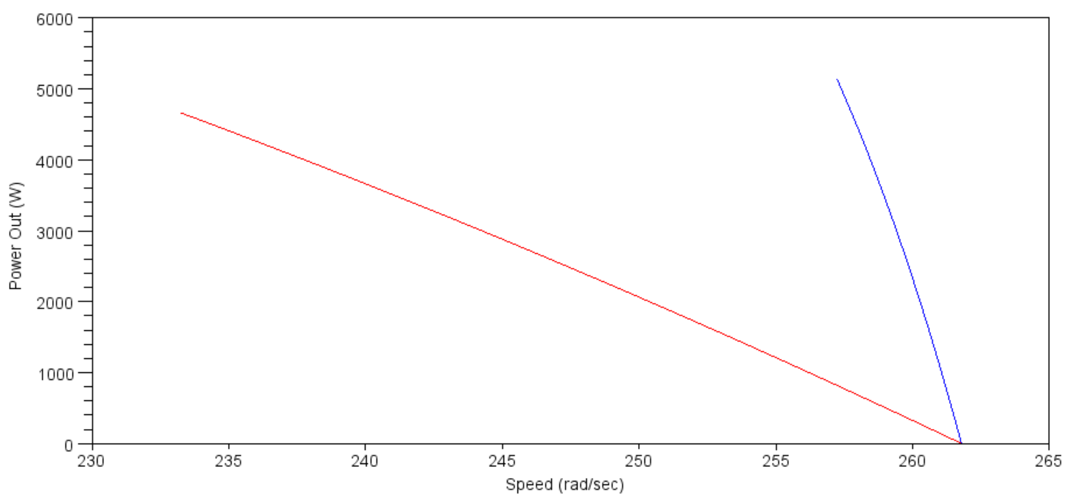
SciLab Code

```
Kt = 0.4584;
Rx = 0.3;
Vt = 120;

T = [0:0.01:20]';

Kt = 0.4584 + 0*T;

for i=1:20
   Ia = T ./ Kt;
   Kt = 0.4584 - 0.001*Ia;
   end

Ia = T ./ Kt;
Ea = Vt - Ia*Rx;
w = Ea ./ Kt;

Po = Ia .* Ea;

If = 120 / 150;

Pin = (Ia + If) * Vt;

eff = Po ./ (Pin);

plot(w,T);
xlabel('Speed (rad/sec)');
ylabel('Torque (Nm)');
```

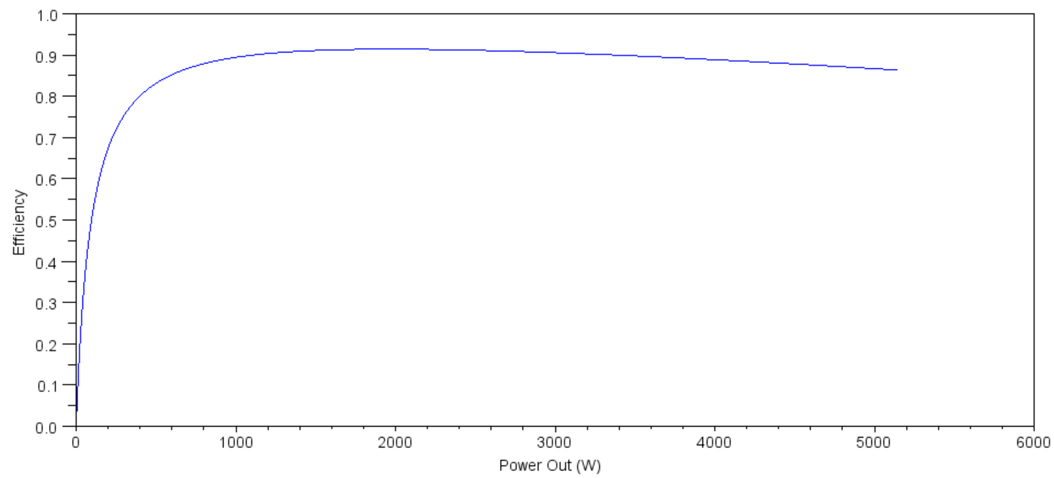
```
plot(w,Po);
xlabel('Speed (rad/sec)');
ylabel('Power Out (W)');

plot(Po, eff);
xlabel('Power Out (W)');
ylabel('Efficiency')
```



Speed vs. Torque with field weakening (blue) and without (red). Note that the speed is regulated much better with the series-shunt configuration (blue)



Speed vs. Power with field weakening (blue) and without (red). Note that the speed is regulated much better with the series-shunt configuration (blue)



Efficiency vs. Load with Field Weakening. Note that the peak efficiancy is near 2000 Watts

2b) Assume the load torque is related to speed. Is this a stable solution?

Yes - the current converged

3) If you weaken the field too much, the motor speeds up as you apply more load.

What happens to the motor if you apply a load related to speed (such as friction)?

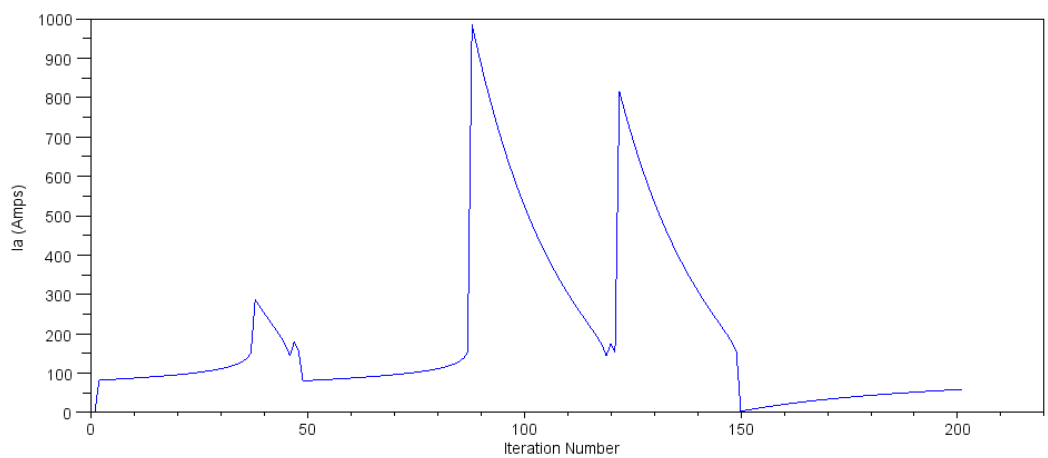
Example:

$$K_t = (0.4584 - 0.003 I_a)\ \frac{Nm}{A}$$

Iterating at 20Nm

```
Kt = 0.4584;
Rx = 0.3;
Vt = 120;

T = 20';

Kt = 0.4584 + 0*T;

Data = [];

Data = 0;

for i=1:20
   Ia = T ./ Kt
   Kt = 0.4584 - 0.003*Ia;
   Data = [Data; Ia];
   end
```

The value of Ia after each iteration is as follows:



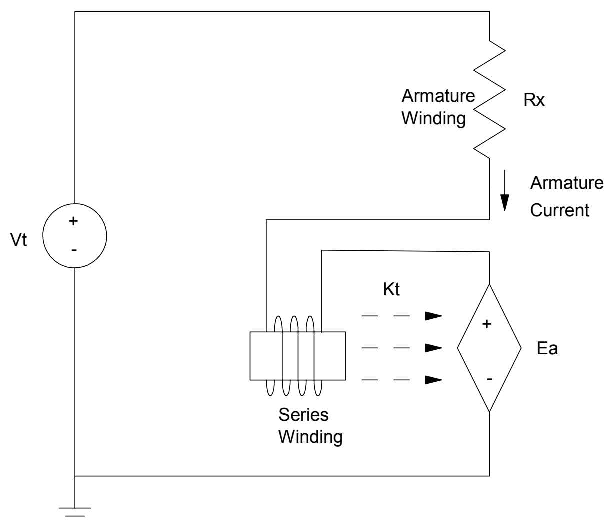
It isn't converging. Current blows up to infinity . The motor tries to fly apart.

4) Assume the motor is wound in a series configuration so that

$$K_t = \left(\frac{I_a}{1000}\right) \frac{Nm}{A}$$

Compute and plot:

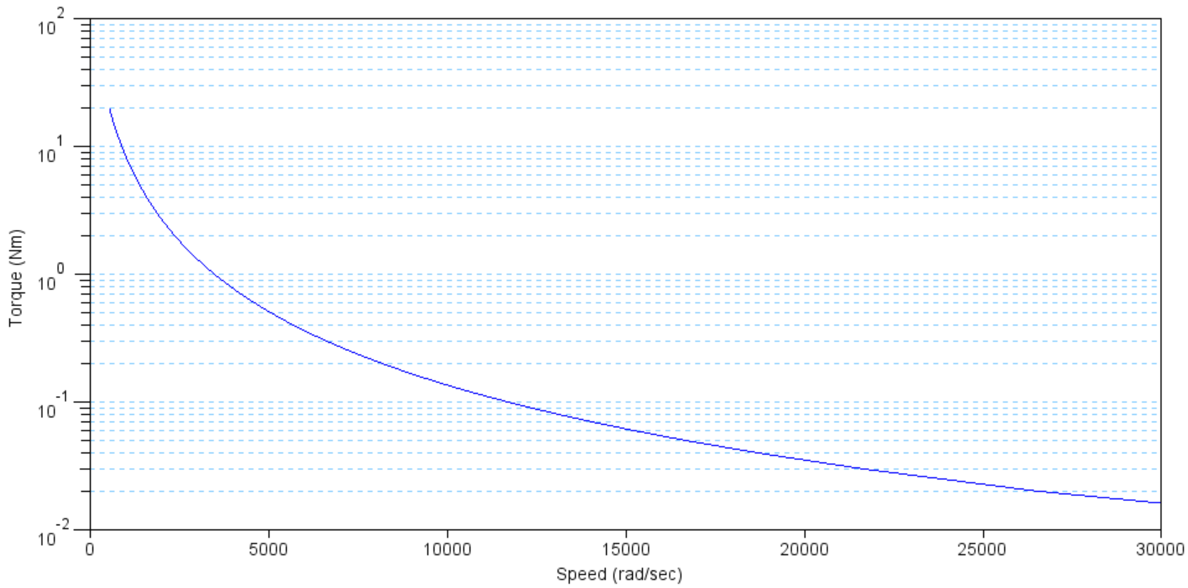
- speed vs. load
- speed vs. power
- power vs. efficiency



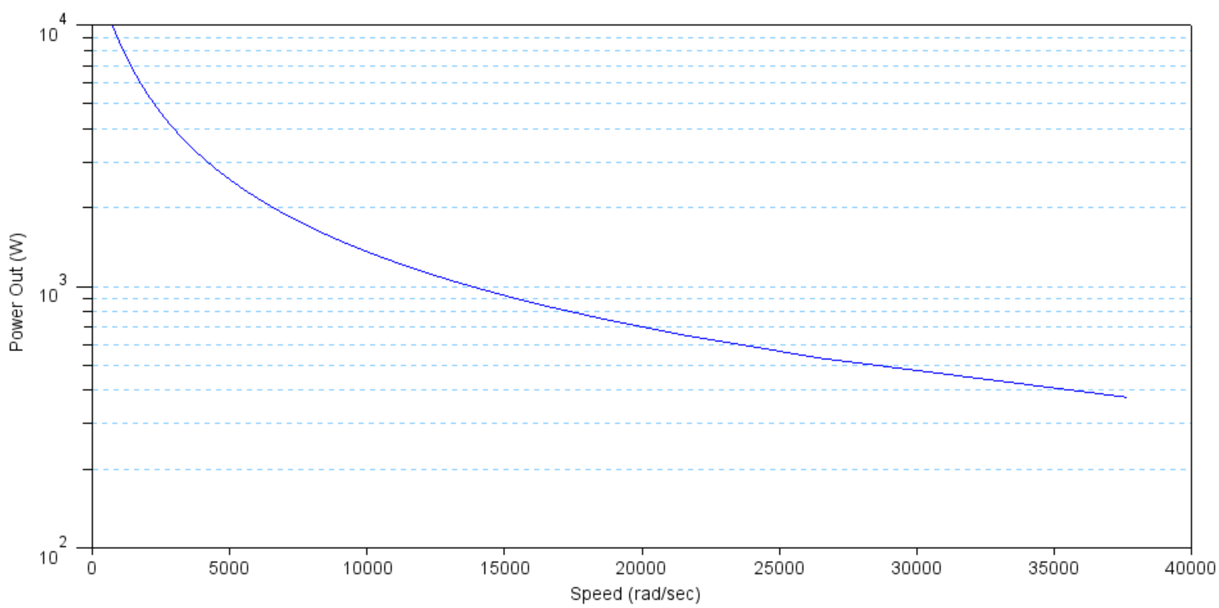
SciLab Code

```
Rx = 0.3;
Vt = 120;

T = [0.01:0.01:20]';

Ia = (T * 1000) .^ 0.5;

Kt = Ia / 1000;


Ea = Vt - Ia*Rx;
w = Ea ./ Kt;

Po = Ia .* Ea;

If = 120 / 150;

Pin = Ia * Vt + 0.001;

eff = Po ./ (Pin);

plot(w,T);
xlabel('Speed (rad/sec)');
ylabel('Torque (Nm)');

plot(w,Po);
xlabel('Speed (rad/sec)');
```

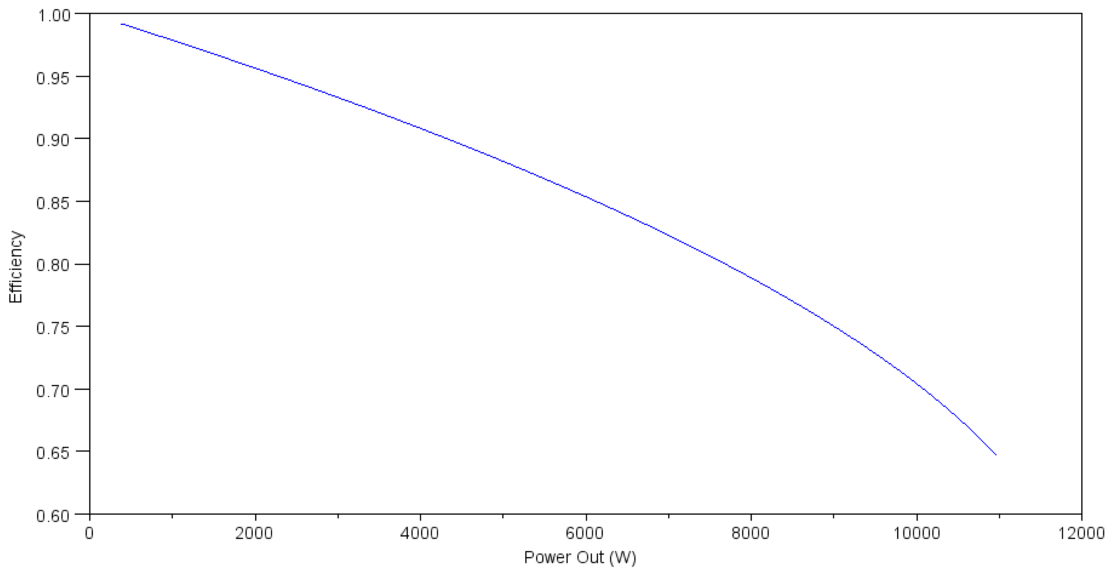
```
ylabel('Power Out (W)');

plot(Po, eff);
xlabel('Power Out (W)');
ylabel('Efficiency')
```



Speed vs. Torque. Note that as the torque goes to zero, the speed takes off to infinity (bad)



Speed vs. Power. Note that the power out is always non-zero. If there is no load, there is nowhere for the power to go other than speeding up the motor



Power vs. Efficiency. Efficiency isn't bad at low loads

5) What happens to this motor if the load is removed?

ans:

The motor tries to speed up to infinity.

It speed up until mechanical failure (it blows apart)