ECE 331 - Homework #10

DC Permanent Magnet Motors. Due April 23th, 4PM

A single SM24580 DC servomotor is to be used for an RC car.

http://www.motiontek.ca/dcservomotor.html

1) Determine (or estimate) the motor parameters: Kt, Ra, La, Inertia, Friction

SM34580E500S $225 CA
500 CPR, single ended Encoder
Latching connector, cable 4'

SM34580 $125 CA
Brushed DC motor only

Contact us for Viper 95 Driver & all required Connectors

SM34580 Servo Motor Specification Download Motor SM34580.pdf	
Frame Size	Nema34
Constant Torque	118 oz/in – 0.8 N.M
Peak Torque	580 oz/in – 4.09 N.M
Continuous Current	7.3 Amp
Peak Current	38 Amp
Maximum Speed	5800 RPM ±10 % at 90V 3600 RPM ±10 % at 50V
Resistance	0.993 ohm
Inductance	1.75 mh
Inertia	3.42 kg/cm^2
Terminal Voltage	90 VDC
US Digital E5 Encoder single end	

$$K_t = \frac{90V}{5800rpm} = \frac{90V}{607.37\text{rad/sec}} = 0.1482\frac{Vs}{rad}$$ (from maximum speed)

$$K_t = \frac{0.8Nm}{7.3A} = 0.1096\frac{Nm}{A}$$ (from continuous torque & current)

$$K_t = \frac{4.09Nm}{38A} = 0.1076\frac{Nm}{A}$$ (from peak torque & current)

Ra = 0.993 Ohms (from datasheet)

La = 1.75 mH (from datasheet)

Inertia = 0.000342 $kg \cdot m^2$ (from datasheet)

Friction: unknown

One comment from battlebots is small wheels give your torque while large wheels give you speed.

Assume you have a 90VDC power supply.

2) Plot the torque vs. speed for this motor assuming it directly drives a wheel with a diameter of 3cm

$$x = r\theta$$

$$v = \frac{dx}{dt} = r\frac{d\theta}{dt} = r\omega$$

$$v = 0.03\omega$$

$$E_a = K_t\omega = \left(0.1096\frac{V}{rad/\sec}\right)\omega$$

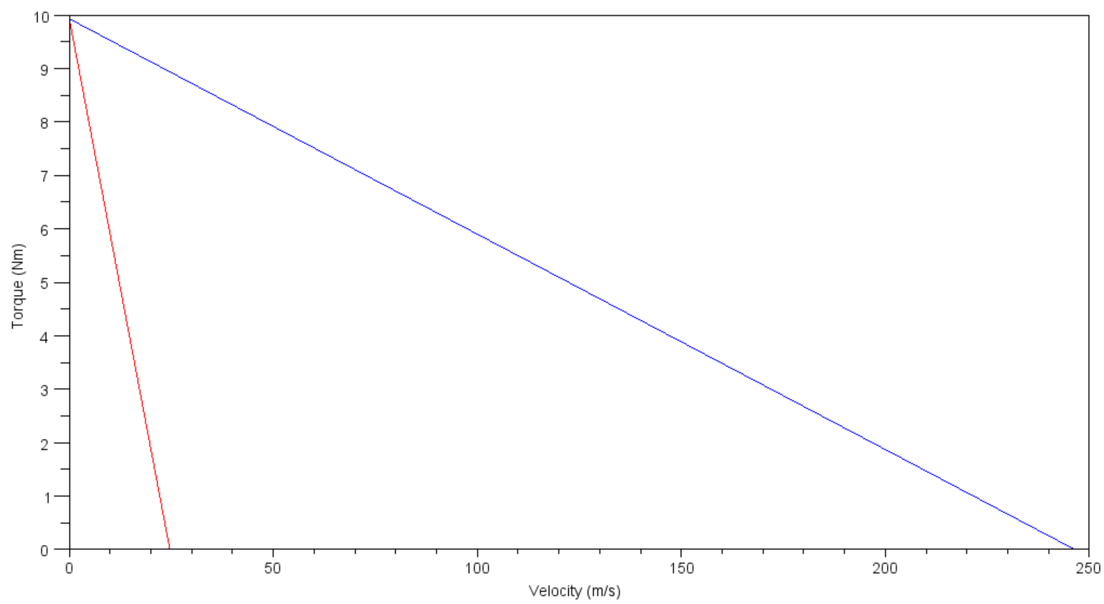
$$I_a = \frac{90V - E_a}{R_a}$$

$$T = K_t I_a$$

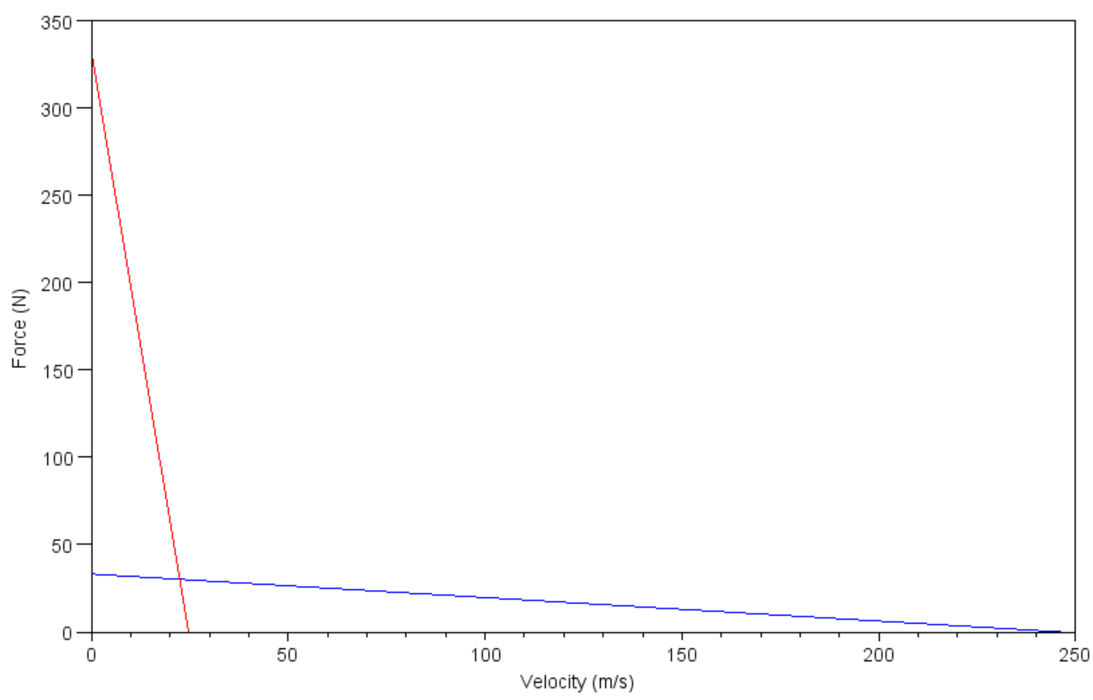
MATLAB Code:

```
-->Kt = 0.1096;
-->Vt = 90;
-->Wmax = Vt / Kt

    821.16788

-->r = 0.03;
-->Vmax = Wmax * r

    24.635036

-->V = [0:0.001:1]' * Vmax;

-->W = V / r;
-->Ea = Kt * W;

-->Ra = 0.993;
-->Ia = (90 - Ea) / Ra;
-->T = Kt * Ia;

-->plot(V, Ia)
-->xlabel('Velocity (m/s)');
-->ylabel('Current Ia (A)');
```

3) Plot the torque vs. speed for this motor assuming it directly drives a wheel with a diameter of 30m



Speed vs. Torque for 3cm wheels (problem 2: red) and 30cm wheels (problem 3: blue)



Speed vs. Force for 3cm wheels (red) and 30cm wheels (blue)

Assume your RC car has a mass of 20kg. Determine the time it takes your car to complete a 100m race

4) With 3cm wheels

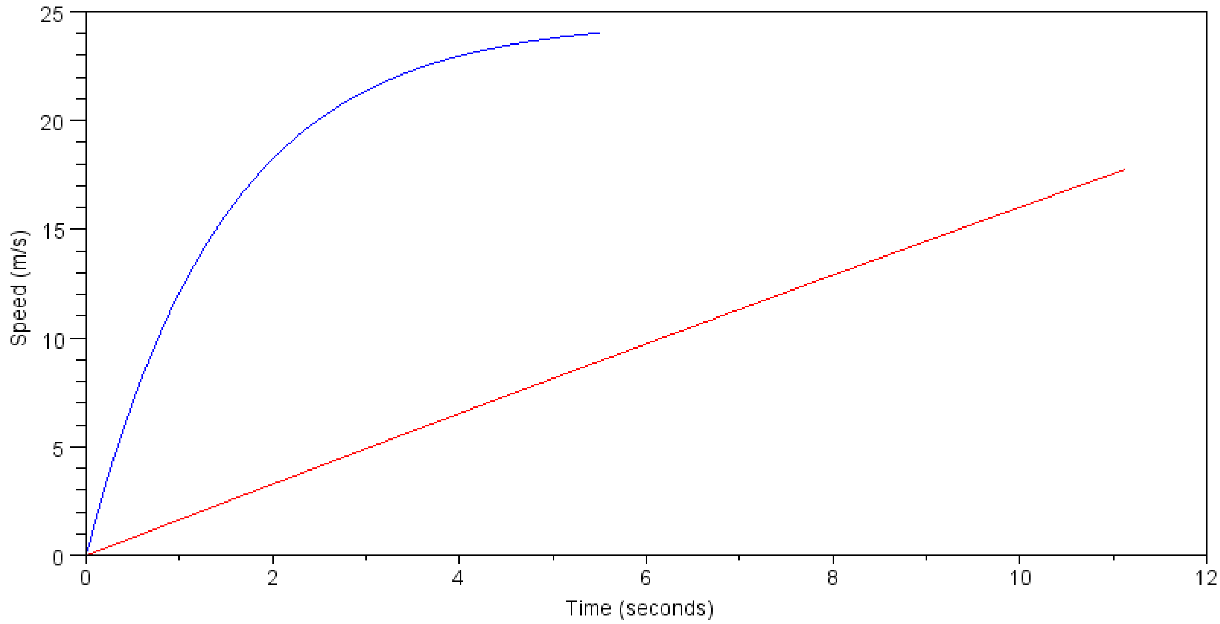
5.51 seconds (approx)

5) With 30cm wheels

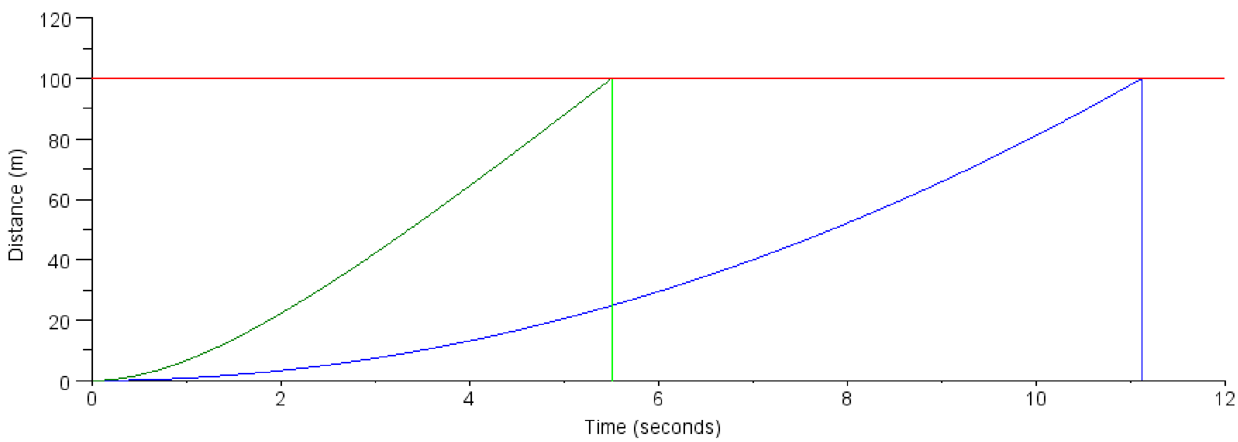
11.13 seconds (approx)

These are found using numerical integration for the motor / cart systems:

```
dt = 0.01;
x = 0;
v = 0;

Kt = 0.1096;
Vt = 90;
r  = 0.3;
Ra = 0.993;

X1 = [];
V1 = [];
t = 0;

while(x<100)
   t = t + dt;
   w = v / r;
   Ea = Kt * w;
   Ia = (90 - Ea) / Ra;
   T = Kt * Ia;
   F = T / r;
   dv = F/20;

   v = v + dv*dt;

   x = x + v*dt;

   V1 = [V1; v];
   X1 = [X1; x];

   end

t = [1:length(X1)]' * dt;

plot(t,V1, 'r');
```



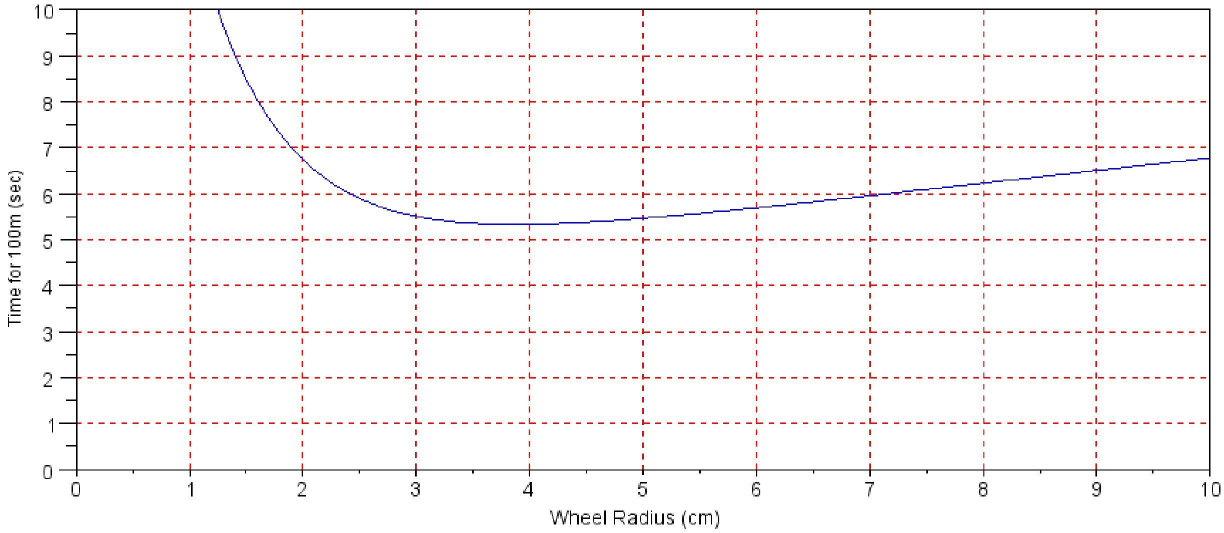
Speed vs. Time for 3cm wheels (blue) and 30cm wheels (red)



Position vs. Time for 3cm wheels (green) and 30cm wheels (blue)

6-7) What is the optimal diameter of wheel for this motor / car combination in a 100m race?

About 4cm;




```
dt = 0.01;
x = 0;
v = 0;

Kt = 0.1096;
Vt = 90;
r  = 0.3;
Ra = 0.993;

TIME = [];

t = 0;

for j = 1:100

   r = j*0.001;
   t = 0;
   x = 0;
   v = 0;

   while(x<100)
      t = t + dt;
      w = v / r;
      Ea = Kt * w;
      Ia = (90 - Ea) / Ra;
      T = Kt * Ia;
      F = T / r;
      dv = F/20;

      v = v + dv*dt;

      x = x + v*dt;
```

```
      end

   TIME = [TIME ; t];
   end

R = [1:100]' * 0.001;
plot(R, TIME)
```