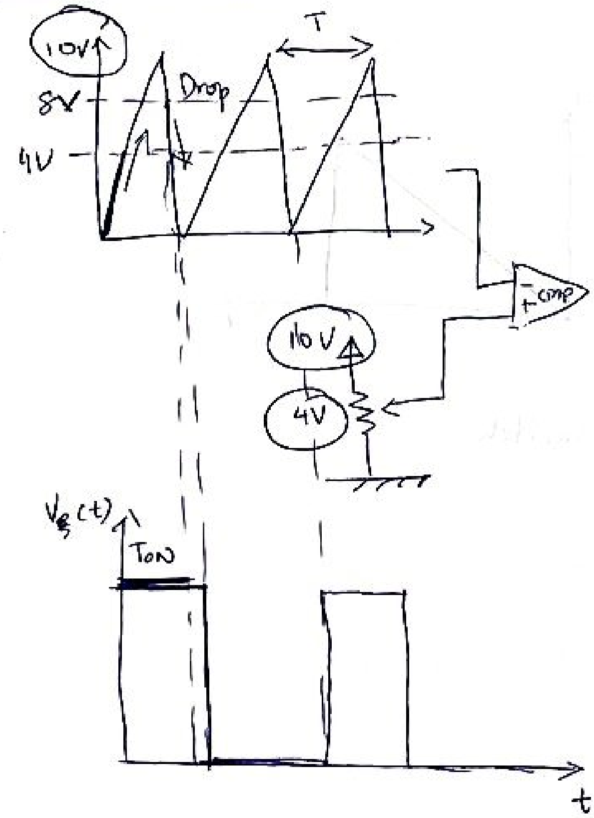
MA 2011 - Tutorial 3

1.



o/p is high → 4V > ramp

o/p is low → 4V < ramp

(i) 100% duty cycle can be achieved.

(ii) $P_{max} = ?$

$$I = \frac{V}{R_{LD}} = \frac{100V}{10\,\Omega} = 10A$$

$$P_{max} = I \cdot V = 10A \cdot 100V = 1kW$$

(iii) $P_{40\%} = 40\%$ of $P_{MAX} = 40\%\ 1kW = 400W$

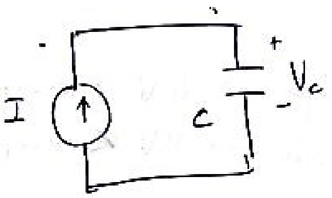
(iv) Double V_c to double the power.

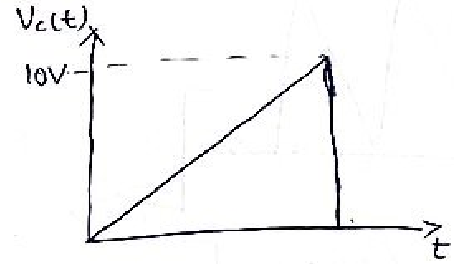
(v) Two conditions

(a) Constant current

(b) No current constant

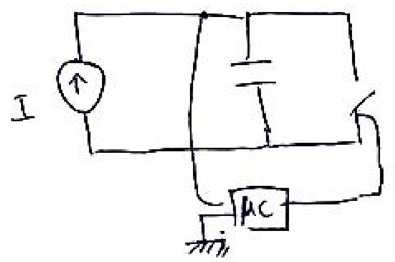
Constant current



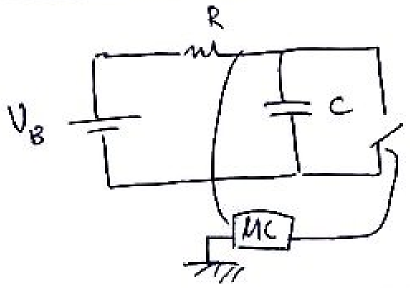


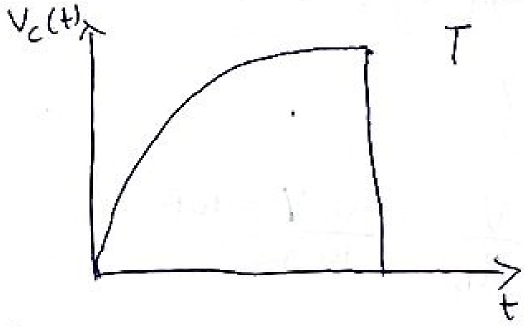
$$i_c = C \cdot \frac{dv}{dt} V_c$$

Solution $\longrightarrow$ Connect a switch

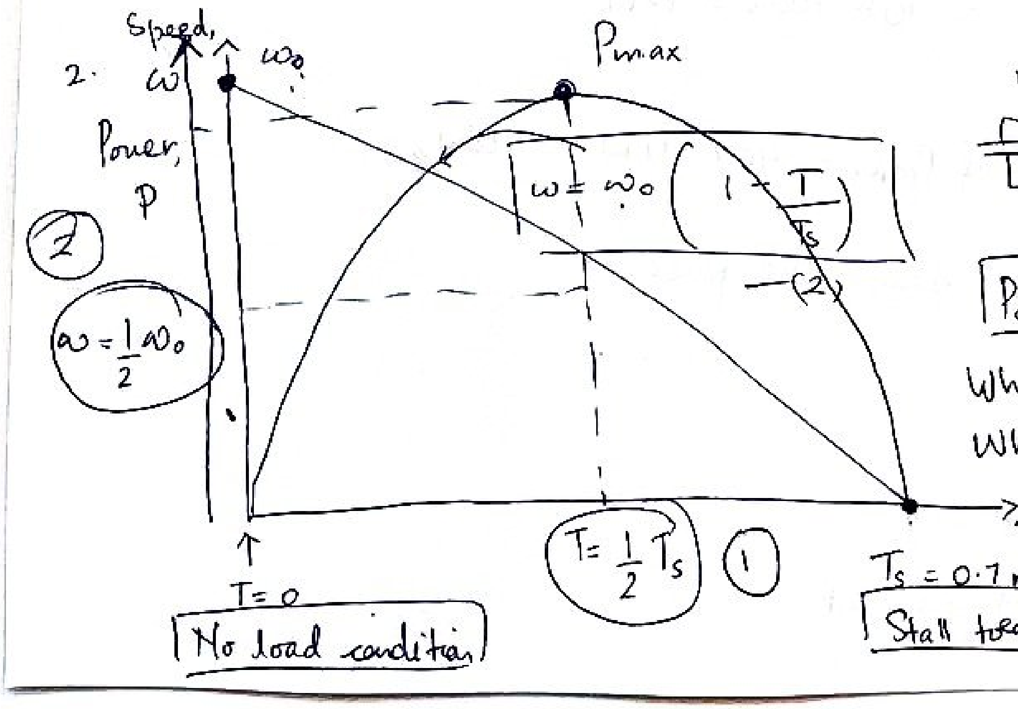


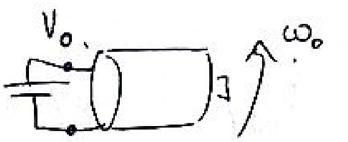
No constant current





2.





$\boxed{P_{out} = \omega \cdot T}$ —(1)

When $T=0$, $\omega = \omega_0$

When $T = T_s$, $\omega = 0$

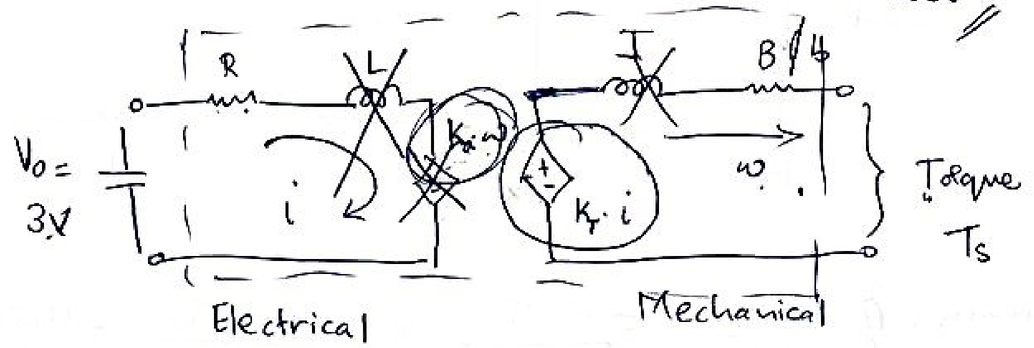
Sub. (2) in (1),

$$P_{out} = \omega_0 \left(1 - \frac{T}{T_s} \right) \cdot T$$

(i) $$P_{out}^{max} = \frac{1}{2}\omega_0 \cdot \frac{1}{2} T_s = \frac{1}{4} \omega_0 \cdot T_s = \frac{1}{4} \cdot 18108 \cdot \frac{2\pi}{60} \cdot 0.7$$

$$= 332\,mW$$

(ii)



? $K_a \cdot \omega = 0$

Assume we set $\omega = 0$

$\boxed{\text{Stall condition}}$

$$R = \frac{V_0}{i} \; ?$$

$$= \frac{V_0}{I_s} = \frac{3V}{422mA} = 7\Omega$$

(iii) Assume the stall condition, $\omega = 0$

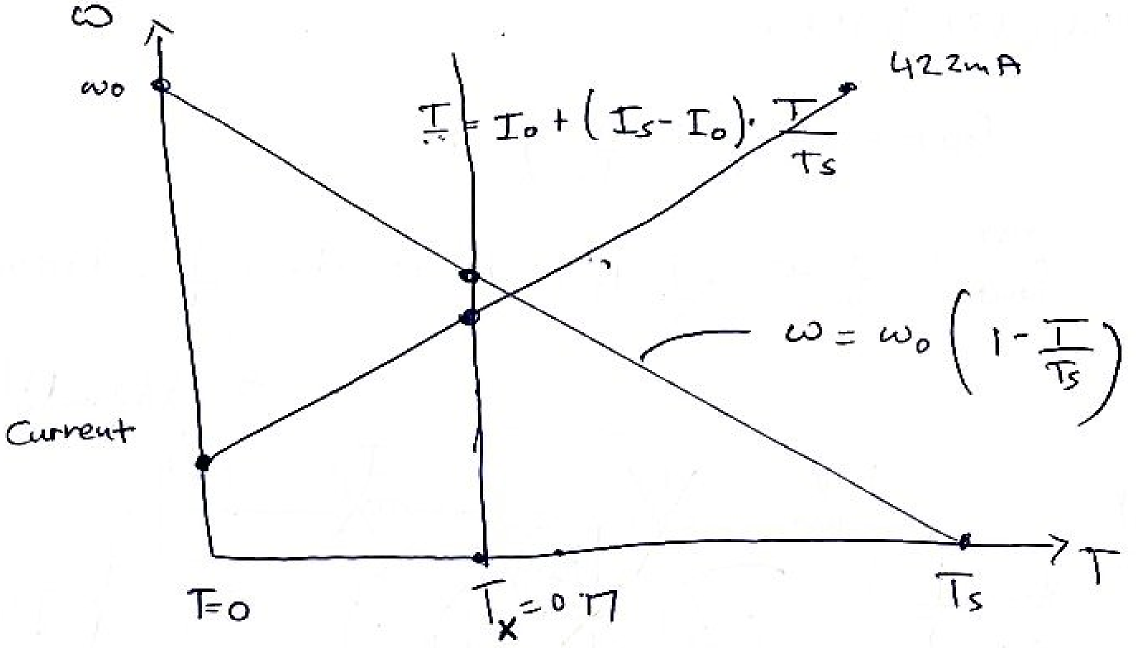
$$k_T \cdot i = T_s$$

$$k_T \cdot I_s = T_s$$

$$k_T = \frac{T_s}{I_s} = \frac{0.7}{422} = 0.0017\,Nm/A$$

$T_s = 0.7\,mNm$

$T = 0.\,?\,mNm$



Efficiency, $\eta = \frac{P_{out}}{P_{in}} = \frac{\omega \cdot T}{V_o \cdot I} = \frac{\omega_x \cdot T_x}{V_o \cdot I_x} = \frac{1435 \cdot 0.17}{3 \cdot 137}$

$= 59\%$

No load current = 46mA —(1)

Stall current: 422mA —(2)

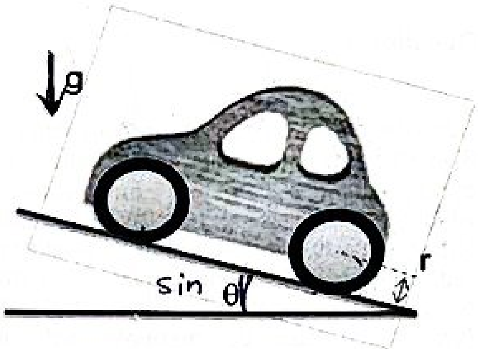
$$\omega_x = w_o\left(1 - \frac{T_x}{T_s}\right) = 1435 \text{ rad/s}$$

$$I_x = I_o + (I_s - I_o) \cdot \frac{T_x}{T_s} = 137\text{mA}$$

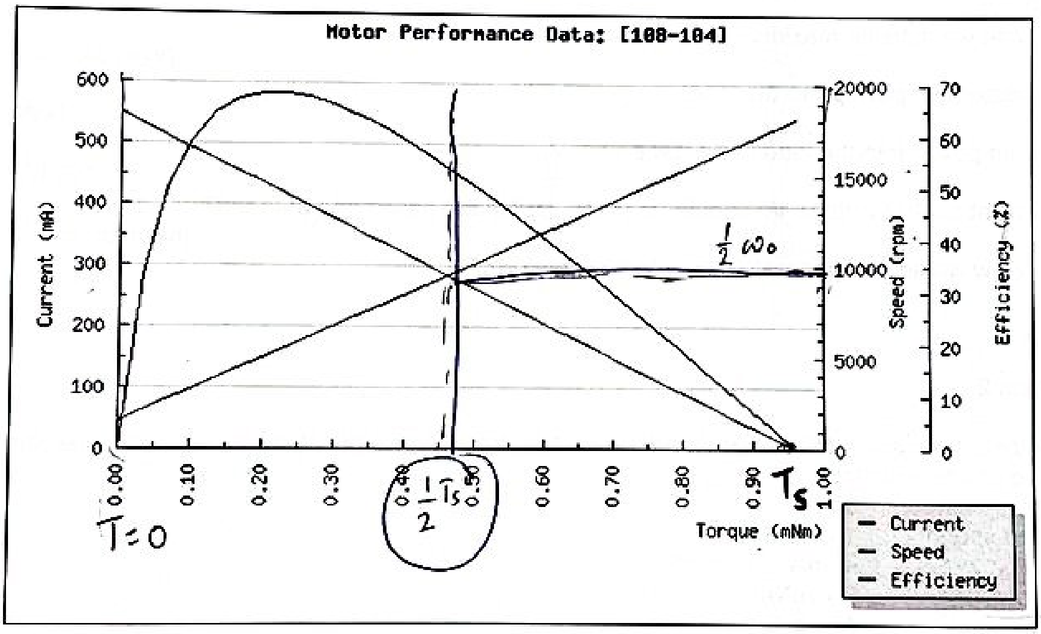
$F = Mg = \frac{1}{2} Mg$

Question 3

You should build a radio-controlled toy car, as in the figure. To make it steer, the easiest way is to use two motors directly mounted on the axes of the rear wheels (one per wheel).
The final estimated weight of the car is M=20g.
As a requirement, it should be able to run on a θ=30 degrees slope.



Neglecting friction, determine the radius of the wheels r that allows the car to move at maximum output power and the output linear speed when the motor has the following characteristics:



[r=9.4mm; v=8.86 m/s]

$$T = \frac{1}{2} T_s$$

$$F = Mg = \frac{1}{2} Mg$$

$$T = r \cdot F = \frac{1}{2} Mgr = \frac{1}{2} Mgr\sin\theta$$

$$\frac{1}{2} T_s = \frac{1}{2} Mgr \cdot \sin\theta$$

$$r = 9.4\,mm$$

d.campolo@ntu.edu.sg

$$V = \omega \cdot r = \frac{1}{2}\omega_0 \cdot r = \frac{1}{2} \cdot 18000 \cdot \frac{2\pi}{60} \cdot 9.4$$

$$= 8.86\,m/s$$