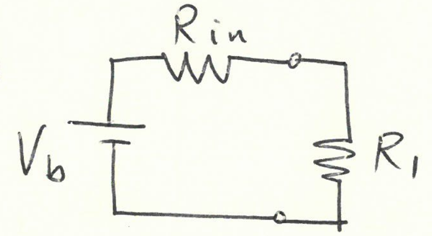
COUNT FLAPULA !

a)




$R_{in} = 0.32\ \Omega$

$V_b = 6\ V$

$R_1 = ?$ (see part b)

b) motor current = 960 mA at full speed
= Total current flow in circuit in part a)

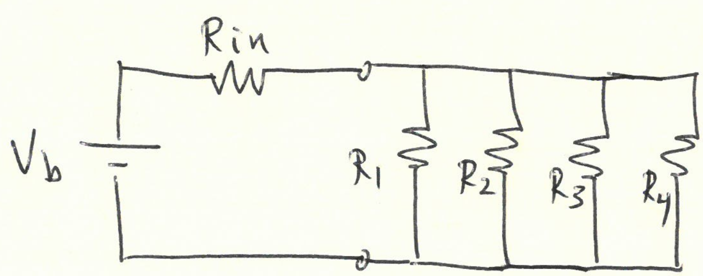
$$i_{max} = \frac{V_b}{R_{in} + R_1}$$

$$R_{in} + R_1 = \frac{6V}{960\ mA}$$

$$= 6.25\ \Omega$$

$$R_1 = 6.25\ \Omega - 0.32\ \Omega = \boxed{5.93\ \Omega}$$

c) All motors plug in parallel to the battery.
This connects all motors to the same two battery terminals



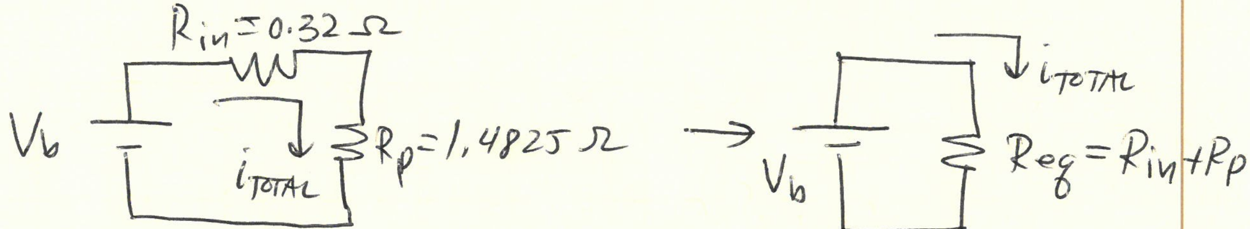
d) $R_1 = R_2 = R_3 = R_4 = R_m = 5.93\,\Omega$.

These are all in parallel giving ~~total~~ parallel equivalent $R_p = \frac{5.93\,\Omega}{4} = 1.4825\,\Omega$

This can be easily computed using $\frac{1}{R_p} = \sum \frac{1}{R_i}$

Or, more intuitively, there are 4 paths for current to flow, so the resistance is 4x less (conductance is 4x greater).

Now for total equiv resistance, we just add the battery internal resistance in series

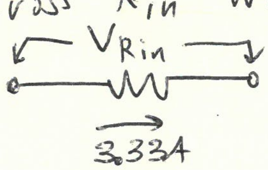



$$R_{eq} = 1.4825 + 0.32\,\Omega = \boxed{1.8025\,\Omega}$$

e) The total current flow $i_{TOTAL} = \frac{V_b}{R_{eq}} = \frac{6V}{1.8025\,\Omega}$

$= \underline{3.33\text{ A}}$

Thus across $R_{in}$ we have

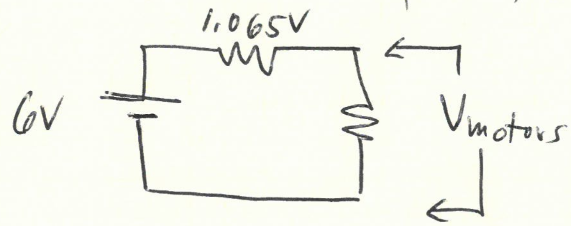



Ohm's Law $\Rightarrow V_{R_{in}} = i_{TOTAL} R_{in}$

$= (3.33A)(0.32\,\Omega)$

$= \underline{\underline{1.065\text{ V}}}$

e cont'd) For the 4 motors, we can use KVL to find that voltage drop is:




$$6V - 1.065V = V_{motors}$$

$$\underline{\underline{V_{motors} = 4.935V}}$$

The total current splits 4 ways, equally across all motors, since they are all the same motor: $i_{motor} = \frac{i_{TOTAL}}{4} = \underline{\underline{0.832\,A}}$

f) Battery charge is $q = 1600$ mAh

$$i_{TOT} = \frac{\Delta q}{\Delta t} \qquad \Delta t = \Delta q / i_{TOT} = \frac{1600\text{ mAh}}{i_{TOTAL}} = \frac{1.600\text{ Ah}}{3.33\text{ A}}$$

The motors can run for $\underline{\underline{t = 0.48\text{ hr} = 28.8\text{ min}}}$

g) $P = i^2 R$ $\quad$ motors: $P_{motors} = (i_{TOT})^2 (R_p)$

($R_p$ ↑ parallel equiv of all motors)

$$= (3.33A)^2 (1.4825\,\Omega)$$
$$= 16.43\text{ W}$$

battery: $P_{battery} = (i_{TOT})^2 (R_{in})$

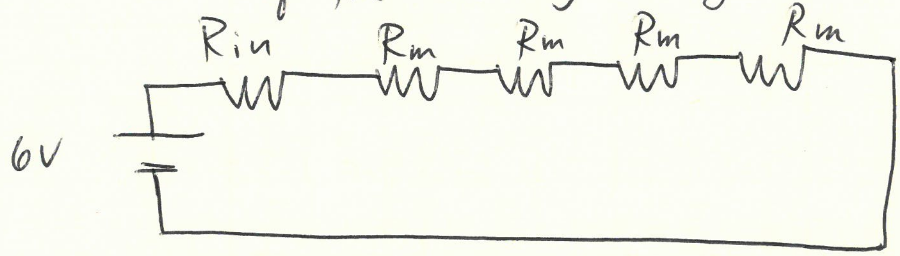
$$= (3.33A)^2 (0.32\,\Omega)$$
$$= 3.55\text{ W}$$

Ratio: $\frac{P_{motors}}{P_{battery}} = \frac{16.43}{3.55} = \underline{\underline{4.63}}$

Note: We lose ~18% of power due to battery resistance

h) Given 6V battery, note 1.5V is $\approx \frac{1}{4}$ of this

What if the motors were connected <u>in series</u>, each motor dropping $\approx 1/4$ of the battery voltage?




Total series resistance $= R_{in} + 4R_m = R_s$

$= 0.32 + 4(5.93\,\Omega)$

$= 24.04\,\Omega$

Total current flow in this case:

$$i_{TOTAL,\,SERIES} = \frac{V_b}{R_s} = \frac{6V}{24.04}\,\Omega \simeq 0.25\,A$$

Voltage drop across one motor

$$V_m = i_{TOTAL,\,SERIES}\,R_m = (0.25A)(5.93\Omega)$$

$$= \underline{1.48\,V}$$

This substantiates the claim about miswiring was putting <u>motors</u> <u>in</u> <u>series</u>