Week 8 Studio 1

Activity 1

supply voltage – rotational speed characteristic for constant load
↳ e.g. toy car
constant load ≈ flat ground
or constant gradient slope

parameter set no = 61 mod 50 + 1
= 12

$V_m = 7.0\,V$

Torque load ≈ $\frac{1}{3}$ of sliding bar

Motor voltage V_m (V)	Rotational speed N (RPM)
7	971
8	1260
9	1572
10	1962
11	2366
12	2525

$$\omega = \frac{V_m - R_m I_m}{k_e}$$

Torque ≈ constant ⇒ $I_m \propto$ Torque
R_m, k_e, I_m constant ⇒ plot is linear

$N = 327.94\,V_m - 1339.5$

The graph would not pass through the origin as $V_m \neq 0$ when $N = 0$

Activity 2

Force exerted on current - carrying conductor $F = BIL \sin\theta$

For PMDC, B, I, θ are constant $\Rightarrow$ $T_{shaft} = k_t I_m$

I_m - ω relationship for a fixed motor voltage V_m

2.

Torque load ~~setting~~	Motor current I_m (A)	RPM	Angular speed ω (rad/s)
~2/3 range	0.83	564	59.1
~1/2 range	0.64	1306	136.8
~1/3 range	0.44	2235	234.0
~1/6 range	0.20	3020	316.3
~1/10 range	0.15	3377	353.6

$$\omega = 2\pi \frac{RPM}{60}$$

$$\omega = \frac{V_m}{k_e} - \frac{R_m I_m}{k_e} \Rightarrow I_m = \frac{V_m - \omega k_e}{R_m}$$

$$= -0.0023\,\omega + 0.9687$$

5. stall current when $\omega = 0$ $\Rightarrow$ $I_m = 0.9687$ A

6. no load speed when $I_m = 0$ $\Rightarrow$ $\omega = \frac{0.9687}{0.0023} = 421 \text{ rad s}^{-1}$

$= 4020$ RPM

In a practical motor, no load speed accounts for frictional torque present

small current still needed to maintain motor speed even with no ext load

7. $R_m = \frac{V_m}{I_m}$ when $\omega = 0$

$= \frac{12.0}{0.9687} = 12.4\,\Omega$

$k_e = \frac{V_m}{\omega}$ when $I_m = 0$

$= 0.028$ Vs/rad

8. $T_{shaft} = k_t I_m$

$k_t = k_e$ for PMDC motors

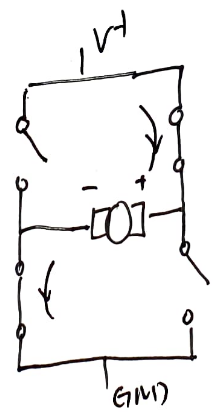
Activity 3

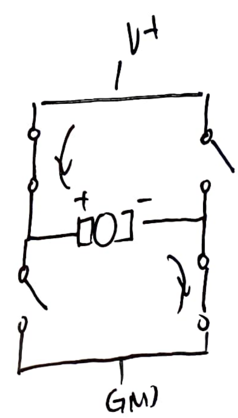
Average terminal velocity varied using PWM = Duty cycle x Supply voltage

$\frac{T_{on}}{T_{period}}$

For a practical motor that needs to be operated bi-directionally, reverse current

by using a H-bridge circuit





Integrated circuit L293D chip is a dual H-Bridge motor controller

contains 2 H-bridges and controls 2 motors

1. upload code
2. connect CH1 to pins 5, 6, 7 to see output
3. change ton to 280 μs ⟹ t_{off} = 220 μs (check with period in Oscope)
4. change tp to 1000 μs ⟹ Duty cycle much lower
5. connect the circuit

   All ground must be common

6.

PWM Frequency (kHz)	t_p (μs)	t_{on} (μs)	PWM noise audible?
1	1000	500	Yes
2	500	250	Yes
4	250	125	Yes
10	100	50	Yes
20	50	25	No

humming from motor caused by torque ripple.

human freq range 20Hz to 20kHz

I would say 4-10 kHz is audible and higher frequency to distinguish from other noise.

7.

Duty Cycle (%)	t_{on} (μs)	RPM
50	25	22
60	30	42
70	35	
80	40	
90	45	
100	50	

↓ increasing trend

V↑ ω↑

8. Add a for loop