

22.1

$$\underline{T_{\text{stall}} @ 15V = 29.5 \text{ Nm}}$$

find V_{min} to support M

$$T_{\text{req}} = \text{radius} \cdot \text{force}$$

$$= \frac{3}{8} m \cdot 10N = \frac{15}{4} \text{ Nm} \quad (1)$$

$$T_{\text{stall}} = k_T \cdot I = k_T \cdot \frac{V}{R} \quad (2)$$

$$T_{\text{stall}} \stackrel{!}{=} T_{\text{req}}$$

$$(1) + (2): k_T \cdot \frac{V}{R} = \frac{15}{4}$$

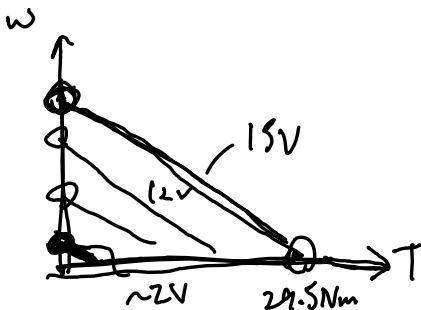
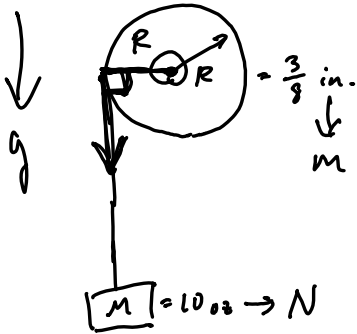
$$\hookrightarrow V = \left(\frac{15}{4} \text{ Nm} \right) \cdot \frac{R}{k_T} \quad (3)$$

motor
characteristic
 $\downarrow$

$$T_{\text{stall}} @ 15V = 29.5 \text{ Nm} = k_T \cdot I = k_T \cdot \frac{V}{R} = (15V) \cdot \frac{k_T}{R}$$

$$\hookrightarrow \frac{k_T}{R} = \frac{29.5 \text{ Nm}}{15 \text{ V}} \quad (4)$$

$$(3) + (4): V = \left(\frac{15 \text{ Nm}}{4} \right) \frac{15 \text{ V}}{29.5 \text{ Nm}} = \frac{225}{128} \text{ V} = \boxed{1.91 \text{ V}}$$



22.3

$$\left. \begin{aligned} K_T &= 105 \text{ mNm/A} \\ R &= 10 \Omega \\ W_{NL} &= 4320 \text{ rpm} \\ V &= 48 \text{ V} \\ T_f &= 55 \text{ mNm} \end{aligned} \right\} \text{given}$$

find ω

$$\begin{aligned} \omega &= W_{NL} - R_M \cdot T \\ &= W_{NL} - \frac{R}{K_T K_e} \cdot T \\ &= 4320 \text{ rpm} - \frac{10 \cancel{\Omega} \cdot 55 \text{ mNm}}{105 \text{ mNm/A} \cdot 11.1 \cancel{\text{V}}/\text{krpm}} \\ &= 4320 \text{ rpm} - \frac{550}{105 \cdot 11.1} \text{ krpm} \\ &= 4.32 \text{ krpm} - 0.472 \text{ krpm} \\ &= \boxed{3.85 \text{ krpm}} \end{aligned}$$

$$\begin{aligned} * W_{NL} &= \frac{V}{K_e} \\ K_e &= \frac{V}{W_{NL}} \\ &= \frac{48 \text{ V}}{4320 \text{ rpm}} \\ &= \frac{48 \text{ V}}{4.32 \text{ krpm}} \\ &= 11.1 \text{ V/krpm} \end{aligned}$$

22.6

$$K_T = 16.1 \text{ mNm/A}$$

$$R = 1.33 \Omega$$

$$\omega_{NL} = 10.3 \text{ krpm}$$

$$V = 18 \text{ V}$$

$$T_{\max} = 24.2 \text{ mNm}$$

} given

find corresponding ω

$$\omega = \omega_{NL} - R_M \cdot T$$

$$= \omega_{NL} - \frac{R}{K_e K_T} \cdot T$$

$$= 10.3 \text{ krpm} - \frac{1.33 \Omega \cdot 24.2 \text{ mNm}}{1.748 \text{ V/(krpm)} \cdot 16.1 \text{ mNm/A}}$$

$$* K_e = \frac{V}{\omega_{NL}}$$

$$= \frac{18 \text{ V}}{10.3 \text{ krpm}}$$

$$= 1.748 \text{ V/(krpm)}$$

$$= 10.3 \text{ krpm} - 1.14 \text{ krpm}$$

$$= \boxed{9.16 \text{ krpm}}$$

22-8

brush: provide contact with the commutator.

supply voltage across a moving boundary

commutator: insulates or conducts current to coils so that torque is generated (through Lorentz force) in the magnetic field established by the stator's magnets. at the right time / in the right sequence.

22.9

$$R = 14.5 \Omega$$

$$T_{\text{stall}} = 4.47 \text{ mNm}$$

$$V = 9 \text{ V}$$

} given

find ω_{NL} (ignore friction)

$$\omega_{NL} = \frac{V}{k_e} *$$

$$= \frac{9 \text{ V}}{0.754 \text{ V/krpm}}$$

$$= \boxed{11.94 \text{ krpm}}$$

$$* T_{\text{stall}} = k_T \cdot I$$

$$= k_T \cdot \frac{V}{R}$$

$$k_T = T_{\text{stall}} \cdot \frac{R}{V}$$

$$= 4.47 \text{ mNm} \cdot \frac{14.5 \Omega}{9 \text{ V}}$$

$$= 7.2 \text{ mNm/A}$$

$$k_e = \frac{k_T}{9.55 \cdot 10^{-3}} = \frac{7.2}{9.55 \cdot 10^{-3}}$$

$$= 0.754 \text{ V/krpm}$$

22.10

$$\left. \begin{aligned} \omega_{NL} &= 11.5 \text{ krpm} \\ T_{\text{stall}} &= 4.47 \text{ mNm} \end{aligned} \right\} \text{given}$$

$$T_{\text{load}} = 1 \text{ mNm}$$

find ω

$$\begin{aligned} \omega &= \omega_{NL} - \underbrace{R_M}_* T \\ &= \omega_{NL} - \frac{\omega_{NL}}{T_{\text{stall}}} \cdot T \\ &= \omega_{NL} \left(1 - \frac{T}{T_{\text{stall}}} \right) \end{aligned} \quad \left| \begin{aligned} * \\ 0 &= \omega_{NL} - \underline{R_M} \cdot T_{\text{stall}} \\ \omega_{NL} &= R_M \cdot T_{\text{stall}} \\ R_M &= \frac{\omega_{NL}}{T_{\text{stall}}} \end{aligned} \right.$$

$$= 11.5 \text{ krpm} \left(1 - \frac{1.0 \text{ mNm}}{4.47 \text{ mNm}} \right)$$

$$= \boxed{8.93 \text{ krpm}}$$