Assignment 3

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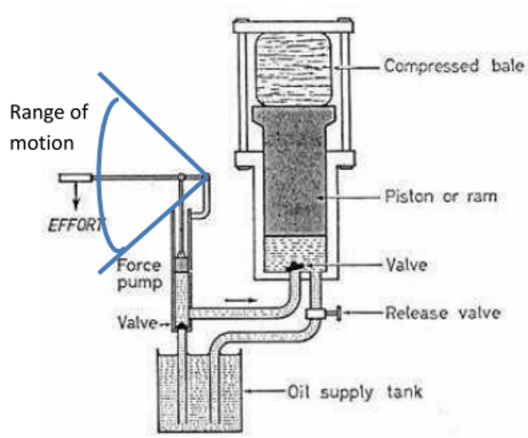
1. For the hydraulic press example done in class, assume that the pump handle can move over a range of 90˚ (from top of stroke to bottom, 45˚ up and down). To raise the hydraulic press by 5", how many times would the operator have to pump the handle?



$$\left\{ \begin{array}{ll} l_{handle} = 0.4\,m & F_{in} = 100\,N \\ l_{pump} = 0.1\,m & F_{pump} = 400\,N \\ A_{pump} = 2\times10^{-5}\,m^2 & F_{out} = 100\,kN \\ A_{piston} = 5\times10^{-3}\,m^2 & P_{max} = 20\,MPa \\ & \\ D_{pump} = 5\times10^{-3}\,m & D_{piston} = 7.97\times10^{-2}\,m \end{array} \right\}$$

$$A_{pump} d_{in} = A_{piston} d_{out}$$

$$d_{in} = \frac{(5\times10^{-3})\left(\frac{5\,in}{39.37\,in/m}\right)}{2\times10^{-5}}$$

$$d_{in} = 31.75\,m \leftarrow \text{total}$$

$$\sin(45°) = 1/\sqrt{2} = (d_{in}/2)/l_{pump}$$

$$1/\sqrt{2} = d_{in}/0.2$$

$$d_{pump} = 0.14142\,m/pump$$

$$\# n = \frac{d_{in}}{} = \frac{31.75\,m}{}$$

$$\# Pumps = \frac{d_{in}}{d_{pump}} = \frac{31.75 m}{0.14142 m/pump}$$

$$= 224.51$$

$$\approx 225 \text{ pumps}$$

2. Instead of using a hydraulic press, your employer now wants you to implement a hydraulic cylinder to provide the same compression (no longer using mechanical advantage of fluid power). The load and displacement requirements stay the same as above. From McMaster-Carr (www.mcmaster.com) select an appropriate hydraulic cylinder, and provide the part number and cost.

$$F_{act} = (100 \times 10^3 N)\left(\frac{0.2248 \text{ lb}}{N}\right) \approx 22480 \text{ lb}$$

$$P_{max} = (20 \times 10^6 Pa)/(6895 \text{ Pa/psi}) \approx 2900.75 \text{ psi}$$

Choose Max Push Force $\geq F_{act}$, $P_{max} \leq 2900.75$

& stroke length $\geq$ 5 inch

Choice: SKU #6220SK195, $1580.81

Max push force: 31420 lbs

Max pressure: 2500 psi

stroke length: 5 in

3. In the 2017 Tour de France, stage nine was won by Rigoberto Uran. During the climb portion of the stage, he averaged 81 rpm, in a 39/30 gear ratio, outputting 378W of power. During the finishing phase in the descent portion, his gearing was damaged, and his derailleur was hit, causing him to experience mechanical issues. The mechanical issues limited him to a single gear option – 53/11, causing his cadence to drop to 70 rpm, but he output 339W of power.

A) For each of these two phases (climb and finish), calculate the output rpm of his rear wheel based on the gear ratio used in Rigoberto's bicycle chain drive.

find output RPM: $(\omega_{out})_c$, $(\omega_{out})_d$

a) $i_c = (\omega_{in})_c / (\omega_{out})_c$

39 _ 81

$a) \quad i_c = (\omega_{in})_c/(\omega_{out})_c$

$$\frac{39}{30} = \frac{81}{\omega_{out}}$$

$$(\omega_{out})_c = 62.31 \text{ RPM}$$

$$i_d = (\omega_{in})_d/(\omega_{out})_d$$

$$\frac{53}{11} = \frac{70}{(\omega_{out})_d}$$

$$(\omega_{out})_d = 14.53 \text{ RPM}$$

B) Given the above information, what torque was he inputting and outputting for each phase? In which phase was he pushing the pedal harder (or were they equivalent)?
C) Assuming a 27" wheel diameter, what was his average road speed during each phase?

$b) \quad H = T\omega$

$$(T_{out})_c = (H_{out})_c/(\omega_{out})_c$$
$$= 378/\left(\frac{62.31 \times 2\pi}{60}\right)$$
$$= 57.93 \text{ N·m}$$

$$i = T_{out}/T_{in}$$

$$(T_{in})_c = (T_{out})_c/i_c$$
$$= 57.93/\left(\frac{39}{30}\right)$$
$$= 44.56 \text{ N·m}$$

$$(T_{out})_d = (H_{out})_d/(\omega_{out})_d$$
$$= 339/\left(\frac{14.53 \cdot 2\pi}{60}\right)$$
$$= 222.80 \text{ N·m}$$

$$(T_{in})_d = (T_{out})_d/i_d$$
$$= 222.80/\left(\frac{53}{11}\right)$$
$$= 46.24 \text{ N·m}$$

$= 46.24\ N\cdot m$

$\therefore$ He was pushing the pedal harder on the descent

c) $V = \omega_{out} r_{wheel}$

$r_w = \frac{1}{2}(27in / 39.37 \frac{in}{m}) = 0.3429 m$

$V_c = \left(\frac{62.31 \times 2\pi}{60}\right) \cdot 0.3429$
$= 2.237\ m/s$

$V_d = \left(\frac{14.53 \times 2\pi}{60}\right) \cdot 0.3429$
$= 0.52175\ m/s$