$L = 2m$

$V_1 = 5 m/s$

$V_2 = 2 m/s$

$\frac{P_1}{w} = 2.5 m$

$$h_L = \frac{0.35 \, (V_1 - V_2)^2}{2g} = \frac{0.35 \, (5-2)^2}{2 \times 9.81} = 0.161 m$$

To get $\frac{P_2}{w}$, comparing:

$$\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2 + h_L$$

$Z_2 = 0$

$Z_1 = 2m$

$$2.5 + \frac{5^2}{2 \times 9.81} + 2 = \frac{P_2}{w} + \frac{2^2}{2 \times 9.81} + 0 + 0.161$$

$$5.77 = \frac{P_2}{w} + 0.365$$

$$\frac{P_2}{w} = 5.77 - 0.365$$

$$= \underline{5.405 m}$$

2. $d_1 = 0.2m$ ; $d_2 = 0.1m$ ; $P_1 = 17.658 N/cm^2$ ; $P_2 = -30 mmHg$ ; $C_d = 0.98$

$$A_1 = \frac{\pi \times 0.2^2}{4} = 3.14 \times 10^{-3} m^2$$

$$A_2 = \frac{\pi \times 0.1^2}{4} = 7.85 \times 10^{-4} m^2$$

$$h = \frac{P_1 - P_2}{w}$$

$$P_1 = \frac{17.658}{10^{-4}} = 176.58 \times 10^3 N/m^2$$

ii.) Fluid power = flow rate × pressure

$= 8.3 \times 10^{-5} \times (15 \times 10^{5})$

$= \underline{124.5\ W}$

iii.) Shaft power = torque × angular velocity

$\omega = 2\pi V$

$= 2\pi \times 28.33 = 178\ rads^{-1}$

Shaft power

$= 15 \times 178$

$= \underline{2670\ W}$

iv.) Overall efficiency $= \frac{\text{fluid power}}{\text{shaft power}} \times 100$

$= \frac{124.5}{2670}$ ~~× 100~~

$= \underline{4.66\%}$

$$\frac{P_1}{w} = \frac{176.58 \times 10^3}{1000 \times 9.81} = 18\,m$$

$$\frac{P_2}{w} = -0.30 \times 13.6$$

$$= ~~-0.048\,m~~ \quad ~~-0.408\,m~~ \quad -4.08$$

$$h = ~~18 - (-0.048~~ \quad ~~18 + 4.08~~ \quad 18 + 4.08$$ 4.

$$~~= 18.408\,m~~$$

$$Q_{act} = C_d \times \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}} \times \sqrt{2gh}$$

$$= 0.98 \times \frac{3.14 \times 10^{-3} \times 7.85 \times 10^{-4}}{\sqrt{(3.14 \times 10^{-3})^2 - (7.85 \times 10^{-4})^2}} \times \sqrt{2 \times 9.81 \times 22.08}$$

$$= 0.98 \times 8.12 \times 10^{-5} \times ~~19~~\ 20.81$$

$$= ~~1.512 \times 10^{-3}\,m^3/s~~ \quad \underline{1.656 \times 10^{-3}\,m^3/s}$$

3. $D_0 = 15\,cm = 0.15\,m$

$D_1 = 30\,cm = 0.3\,m$

$y = 50\,cm\,Hg = 0.5\,m\,Hg$

$S_g$ of oil $= 0.9$ ; $S_g$ of mercury $= 13.6$

$C_d = 0.64$

Area of pipe $(A_1) = \frac{\pi \times 0.3^2}{4} = 0.071\,m^2$

Area of orifice meter $(A_0) = \frac{\pi \times 0.15^2}{4} = 0.0177\,m^2$

$$h = y\left[\frac{S_{hl}}{S_0} - 1\right]$$

$S_{hl}$ = specific gravity of heavier liquid

$$h = 0.5\left[\frac{13.6}{0.9} - 1\right]$$

$$= \underline{7.056\,m \text{ of oil}}$$

$$Q = C_d \frac{A_0 A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_0^2}}$$

$$= \frac{0.64 \times 0.0177 \times 0.071 \times \sqrt{2 \times 9.81 \times 7.056}}{\sqrt{0.071^2 - 0.0177^2}}$$

$$= \underline{0.138\, m^3/s}$$

4. manometer reading $(y) = 170\,mm\,Hg = 0.17\,m\,Hg$

$S_{gHg} = 13.6$

$S_g$ of Seawater $(S_w) = 1.026$

$$h = 0.17 \left[\frac{13.6}{1.026} - 1\right]$$

$$= 2.08$$

Velocity of the submarine:

$$V = \sqrt{2gh}$$

$$= \sqrt{2 \times 9.81 \times 2.08}$$

$$= \underline{6.39\, m/s}$$

5.

$$= \frac{0.64 \times 0.0177 \times 0.071 \times \sqrt{2 \times 9.81 \times 7.056}}{\sqrt{0.071^2 - 0.0177^2}}$$

$$= \underline{0.138\ m^3/s}$$

4\. manometer reading $(y) = 170\,mmHg = 0.17\,mHg$

$S_{gHg} = 13.6$

$S_g$ of sea water $(S_w) = 1.026$

$$h = 0.17\left[\frac{13.6}{1.026} - 1\right]$$

$$= 2.08$$

Velocity of the submarine:

$$V = \sqrt{2gh}$$

$$= \sqrt{2 \times 9.81 \times 2.08}$$

$$= \underline{6.39\ m/s}$$

5\. $Q = 5\,dm^3/min$

$$= \left[\frac{5}{1000} \times \frac{1}{60}\right] m^3/s$$

$$= 8.3 \times 10^{-5}\ m^3/s$$

$$V = 1700\ rev/min = \frac{1700}{60}$$

$$= 28.33\ revs/sec$$

$Q_p = 10\,cm^3/rev = 10 \times 10^{-6}\ m^3/rev$

Ideal flow rate = speed × displacement

$$1 \times 10^{-5} \times 28.33$$

$$= 2.833 \times 10^{-4}\ m^3/sec$$

i) Vol. efficiency $= \frac{\text{actual } Q}{\text{Ideal } Q} \times 100$

$$= \frac{8.3 \times 10^{-5}}{2.83 \times 10^{-4}} \times 100$$

$$= \underline{29.33\%}$$