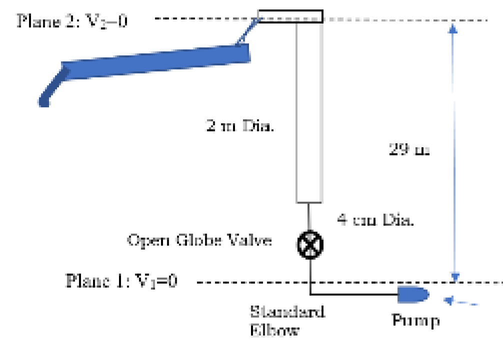
1) A tank of water shown below is to be supplied with the equivalent of 10 meters of water depth in the 2-m diameter tank every 20 minutes, but the water level in the tank remains constant at 20 meters depth owing to the overflow at its top. Ambient pressure prevails at the tank's water surface and the pumping source.

L = total length of straight 4-cm diameter pipe = 20.0 m
f = friction factor of the pipe may be assumed constant at 0.0042.

a) What HP Pump would be required?
b) If a pump of the above calculated size were to be used, at what pressure would the pump need to operate?
c) If a 25 HP pump were selected, what capacity (volume flow rate) of water would be delivered and at what pressure would it need to operate at its exit when running at its maximum rating of 25 HP?
d) Assuming the originally-specified flow rate, what diameter pipe would need to be used if only half the energy to overcome the potential energy term were to be allocated to frictional losses?



$D:=2\cdot m \qquad d:=4\cdot cm \qquad \eta:=10^{-3}\cdot\frac{kg}{m\cdot s} \qquad \rho:=1000\cdot\frac{kg}{m^3} \qquad h:=29\cdot m$

$P_2:=\rho\cdot g\cdot 20\cdot m=1.936\ atm \qquad \beta_2:=1 \qquad f:=0.0042 \qquad L:=20\cdot m$

(a) $Q:=\frac{10\cdot m\cdot\pi\cdot(1\cdot m)^2}{20\cdot min}=0.026\ \frac{m^3}{s} \qquad W:=\frac{10\cdot m\cdot\pi\cdot(1\cdot m)^2\cdot\rho}{20\cdot min}=26.18\ \frac{kg}{s}$

$V_1:=\frac{10\cdot m}{20\cdot min}\cdot\left(\frac{D}{d}\right)^2=20.833\ \frac{m}{s} \qquad F:=2\cdot f\cdot\left(340+31+\frac{L}{d}\right)+0.5\cdot 1.5$

$M:=-\left(0+0+g\cdot h+F\cdot V_1^{\,2}\right)=-3.785\cdot 10^3\ \frac{m^2}{s^2} \qquad HP:=-M\cdot W=132.9\ hp$

(b) $P_1:=P_2+\rho\cdot F\cdot V_1^{\,2}=36.5\ atm$

(c) $w(v):=v\cdot\rho\cdot\pi\cdot\left(\frac{d}{2}\right)^2 \qquad f(v_2):=\left(v_2^{\,2}\left(\frac{1}{2\cdot\beta_2}+F\right)\right)\cdot w(v_2)-25\cdot hp$

$vo:=10\cdot\frac{m}{s} \qquad Q25:=\mathrm{root}\left(f(vo),vo,0\cdot\frac{m}{s},20\cdot\frac{m}{s}\right)\cdot\pi\cdot\left(\frac{d}{2}\right)^2=15.1\ \frac{l}{s}$

(d) $M_{Pot}:=g\cdot h\cdot W=\left(7.445\cdot 10^3\right)\ W \qquad f_E(d_p):=F\cdot\left(\frac{Q}{\pi\cdot\left(\frac{d_p}{2}\right)^2}\right)^2\cdot W-\frac{M_{Pot}}{2}$

$d_0:=10\cdot cm \qquad d_p:=\mathrm{root}\left(f_E(d_0),d_0,4\cdot cm,100\cdot cm\right)=8.91\ cm$

check: $2\cdot F\cdot\left(\frac{Q}{\pi\cdot\left(\frac{d_p}{2}\right)^2}\right)^2\cdot W=\left(7.445\cdot 10^3\right)\ W$