Answer to the Question no: a

For one Building,

Given

Time $t = 2.0$ hours
$= 2 \times 60 \times 60\ s$
$= 7200\ s$

Assuming 1 story $= 3m$

Height of Buiding $= (3 \times 6) = 18\ m$

Length of pipe $L = (2 + 3.2 + 18 + 3 + 4.1)\ m$
$= 30.3\ m$

Diameter of pipe $D = 2.54\ cm$
$= 0.0254\ m$

cross section Area of pipe $A = \frac{\pi}{4} \times D^2 = \frac{\pi}{4}(0.0254)^2$
$= 5.067 \times 10^{-4}\ m^2$

Volume of Tank, $Vol = (5.5 \times 4.5 \times 3.5)\ m^3$
$= 86.625\ m^3$

So,
$\therefore$ Flow Rate $Q = \frac{Vol}{t} = \frac{86.625\ m^3}{7200\ s} = 0.01203\ m^3/s$

again,
Velocity of water $v = \frac{Q}{A}$ $[Q = vA]$
$= \frac{0.01203\ m^3/s}{5.067 \times 10^{-4}\ m^2} = 23.74\ ms^{-1}$

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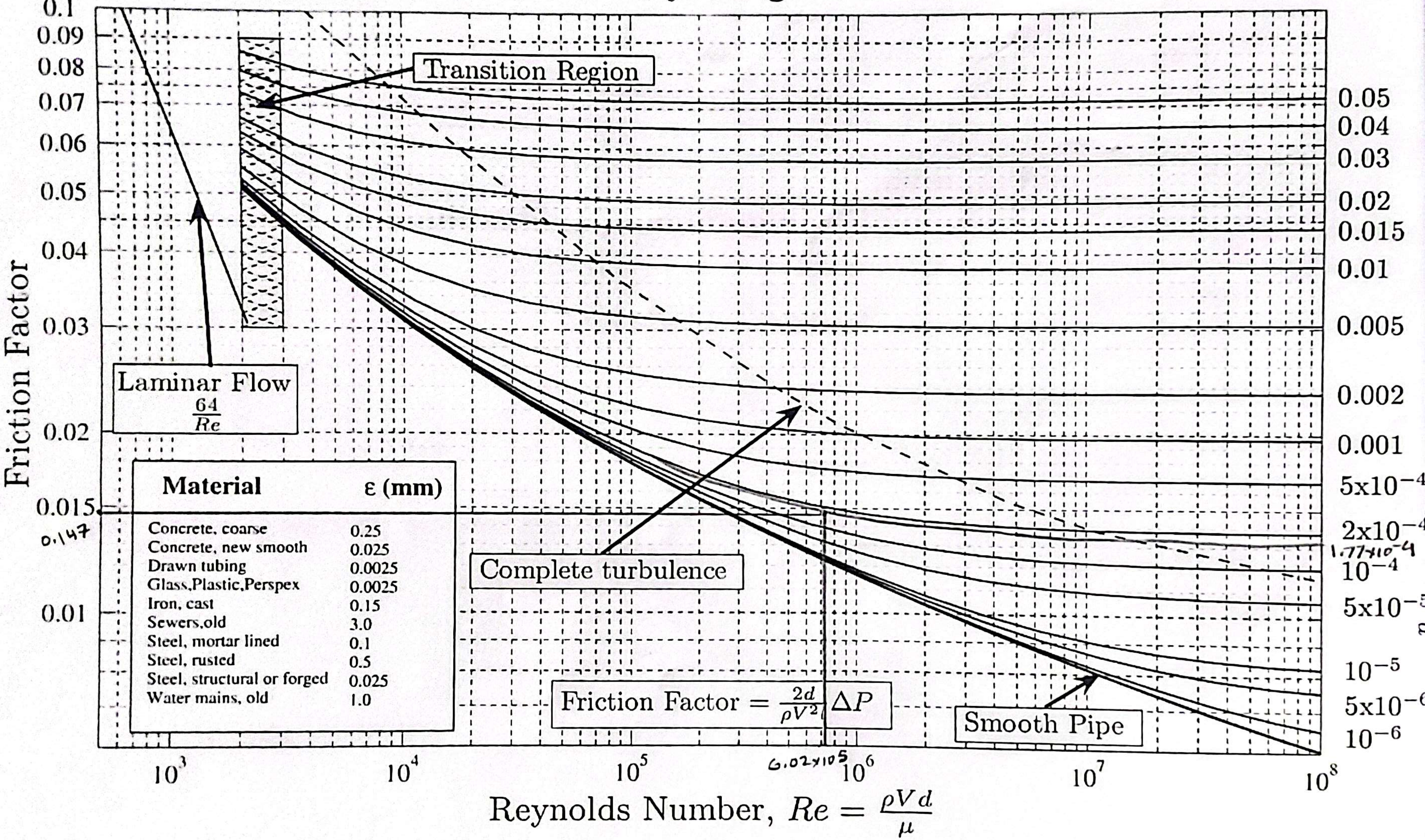
Moody Diagram



Given,

Surface Roughness $\varepsilon = 0.0045$ mm
$= 0.0045 \times 10^{-3}$ m

So

Relative Roughness, $\frac{\varepsilon}{D} = \frac{0.0045 \times 10^{-3} \text{ m}}{0.0254 \text{ m}}$
$= 1.77 \times 10^{-4}$

Now

Raynold's Number

$$Re = \frac{\rho v D}{\mu}$$

$$= \frac{1000 \text{ kg/m}^3 \times 23.74 \text{ m/s} \times 0.0254 \text{ m}}{1.0016 \times 10^{-3} \frac{\text{NS}}{\text{m}^2}}$$

Assuming viscosity $\mu = 1.0016 \times 10^{-3} \frac{\text{NS}}{\text{m}^2}$ at 20°C

$\rho = 1000$ kg/m3

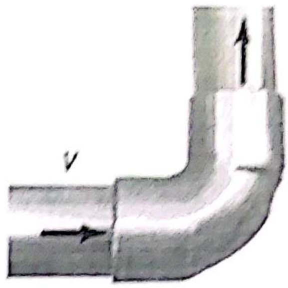
$= 602032.74 > 4000$

So flow is turbulent,

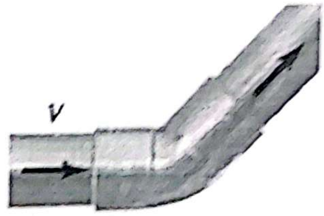
From Moody Diagram,

friction factor $f = 0.0147$

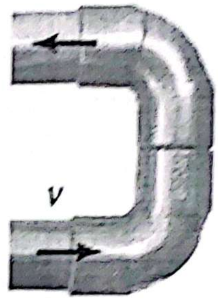
Component	K
a. Elbows	
Regular 90°, flanged	0.3
Regular 90°, threaded	1.5
Long radius 90°, flanged	0.2
Long radius 90°, threaded	0.7
Long radius 45°, flanged	0.2
Regular 45°, threaded	0.4
b. 180° return bends	
180° return bend, flanged	0.2
180° return bend, threaded	1.5
c. Tees	
Line flow, flanged	0.2
Line flow, threaded	0.9
Branch flow, flanged	1.0
Branch flow, threaded	2.0
d. Union, threaded	0.08
***e. Valves**	
Globe, fully open	10
Angle, fully open	2
Gate, fully open	0.15
Gate, $\frac{1}{4}$ closed	0.26
Gate, $\frac{1}{2}$ closed	2.1
Gate, $\frac{3}{4}$ closed	17
Swing check, forward flow	2
Swing check, backward flow	∞
Ball valve, fully open	0.05
Ball valve, $\frac{1}{3}$ closed	5.5
Ball valve, $\frac{2}{3}$ closed	210



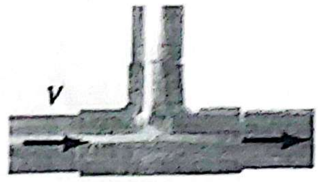
90° elbow



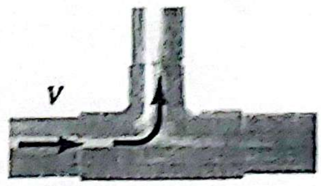
45° elbow



180° return bend



Tee



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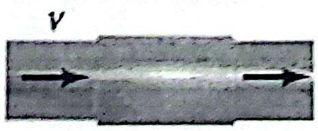

Union

Table: Loss coefficient for pipe components

Bernoulli's Equation,

when pump's are used

$$\cancel{\frac{P_1}{\gamma}}^{\,0} + \cancel{\frac{V_1^2}{2g}}^{\,0} + \cancel{Z_1}^{\,0} + h_{pump} = \cancel{\frac{P_2}{\gamma}}^{\,0} + \cancel{\frac{V_2^2}{2g}}^{\,0} + Z_2 + h_{Lf}$$

in this case,

$$h_{pump} = Z_2 + h_{lf} = Z_2 + h_{lf\,major} + h_{lf\,minor}$$

~~For~~ major Head loss,

for turbulent flow

$$h_{lf\,major} = \frac{f L V^2}{2gD}$$

$$= \frac{0.0147 \times 30.3 \times (23.74)^2}{2 \times 9.81 \times 0.0254}$$

$$= 503.72 \text{ m}$$

For minor Head loss,

we have 4 90° angle (Assuming flanged)

with Loss coefficient $K_L = 0.3$

we have $\cancel{6}$ 5 union (Assuming theaded) with

Loss coefficient $K_L = 0.08$

we have 2 Gate valve (Assuming fully open)

with Loss coefficient $K_L = 0.15$

Now

Minor Head loss $h_{lf\,mionor} = \Sigma K_L \frac{v^2}{2g}$

$$= (0.3\times4 + 0.08\times5 + 0.15\times2) \times \frac{(23.74)^2}{2\times9.81}$$

$$= 1.9\cancel{8} \times \frac{(23.74)^2}{2\times9.81} = \overset{54.57}{\cancel{56.87}}\ m$$

From Building figure,

$$Z_2 = 2 + (3\times6) + 3 = 23\ m$$

From

Bernoulli's Equation,

$$h_{pump} = Z_2 + h_{lf\,major} + h_{lf\,minor}$$

$$= 23 + 503.72 + 56.87\ m$$

$$= 58\overset{1}{\cancel{3}}.\overset{29}{\cancel{59}}\ m$$

So,

Power of Pump $P_{pump} = \rho g Q\, h_{pump}$

$$= 1000 \times 9.81 \times 0.01203 \times \overset{581.29}{\cancel{583.59}}$$

$$= \overset{68600.53}{\cancel{68871.96}}\ watt$$

$$= \cancel{68.67}\ kilo\text{-}watt$$

$$= 68.6\ kilo\text{-}watt$$

Answer to the Ques No: b

Given,

Pump Efficiency $\eta_{pump} = 60\% = 0.6$

Motor Efficiency $\eta_{motor} = 78\% = 0.78$

Machine efficiency $\eta_{machine} = \eta_{pump} \times \eta_{motor}$

$= 0.6 \times 0.78$

$= 0.468 = 46.8\%$

From (a)

P_{pump} or $P_{out} = \cancel{68.87}$ 68.6 Kilo watt

$\therefore \eta_{machine} = \frac{P_{out}}{P_{in}}$

$\Rightarrow P_{in} = \frac{P_{out}}{\eta_{machine}} = \frac{\cancel{68.87}\ 68.6}{0.468} = \cancel{147.158}$ 146.58 Kilo watt

The motor operates 2 time a day for 2 hours

So Time for 30 days or a month

$t = 2 \times 2 \times 30 = 120$ hour

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We know,

Energy = Power x time

$= \cancel{147.158}$ 146.58 kilowatt x 120 hour

$= \cancel{17658.96}$ kilowatt hour

= 17589.74 kilowatt hour

$= \cancel{17658.96}$ unit per month

= 17589.74 unit

$= \cancel{6.357 \times 10^{10}}$ ~~Jute~~ Joule

$= 6.332 \times 10^{10}$ J

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