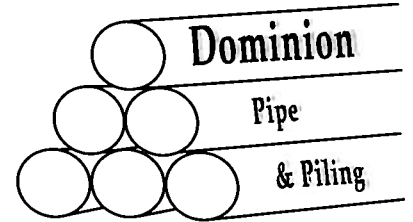


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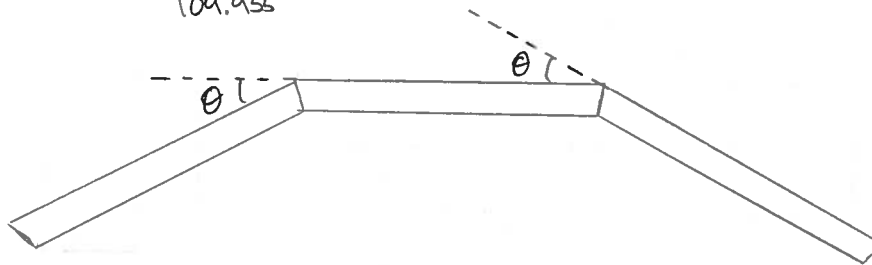
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Skookum Pipe tunnel: coefficient of Friction:
greased hard steel on hard steel
 $\mu = 0.16$ From engineering toolbox

- 140m arc
- pipe lengths = 8m

Finding angle of the joints: $C = 2\pi r$
 $= 2\pi(140)$
 $= 879.65\text{ m}$
 # of pipes = $\frac{C}{l}$
 $= 109.955$
 joint angle = $\frac{360}{\# \text{ of pipes}}$

$$\theta = \frac{360}{109.955} = 3.274^\circ$$



Pipe weights:

FRP: $D = 2043$ $W = 418 \text{ kg/m}$ $\therefore m = 418(6) = 3344 \text{ kg}$
 $D = 1829$ $W = 340 \text{ kg/m}$ $m = 2720 \text{ kg}$
 STEEL: $D = 1981$ $W = 461.9 \text{ kg/m}$ $m = 3695.2 \text{ kg}$
 $D = 1829$ $W = 426.3 \text{ kg/m}$ $m = 3410.4 \text{ kg}$

From:
Y: 1005PP/325 Penstock/
FRP & STEEL Penstock
lengths - 20110302

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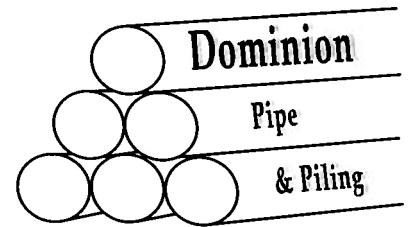
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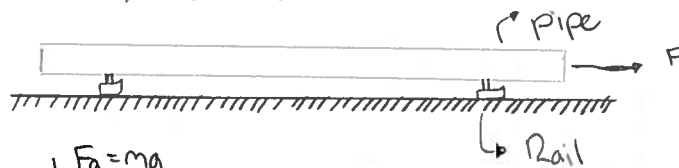
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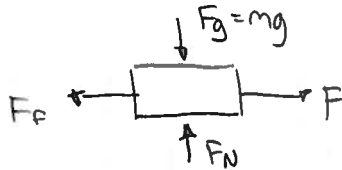
Finding Friction Forces Page 1

Case 1: Pipe on a straight section (no corners)

Side View:



EBD:



$$F = F_f = \mu F_N = \mu mg$$

- ①: $F_1 = 0.16 (3344)(9.81) = 5248.74 \text{ N}$
- ②: $F_2 = 0.16 (2720)(9.81) = 4269.312 \text{ N}$
- ③: $F_3 = 0.16 (3696.2)(9.81) = 5799.99 \text{ N}$
- ④: $F_4 = 0.16 (3410.4)(9.81) = 5352.96 \text{ N}$

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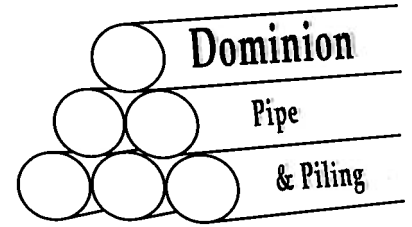
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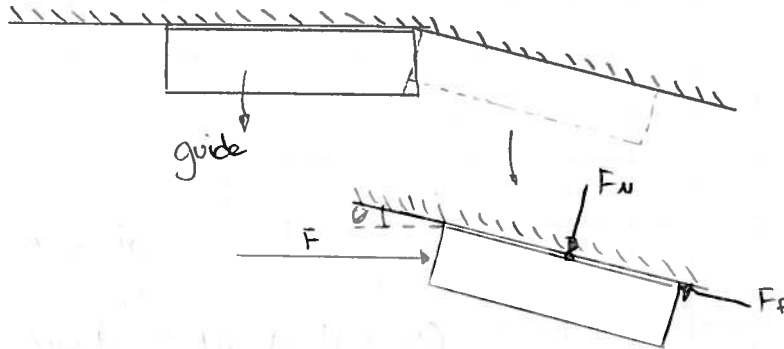
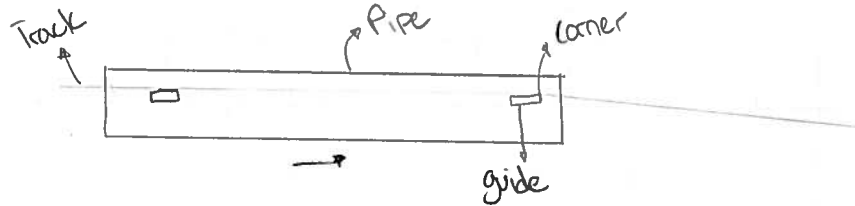
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Finding Friction Forces: Page 2

Case 2: Pipe hits the corner

IF the guide is a roller,
it would change direction very
easily

TOP VIEW:

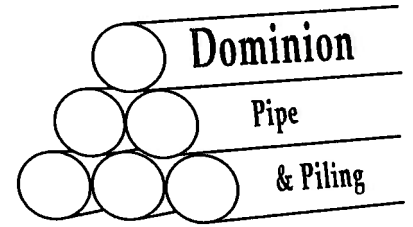


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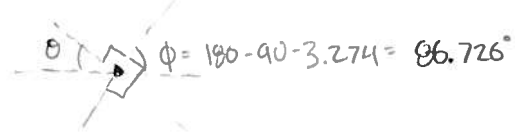
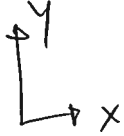
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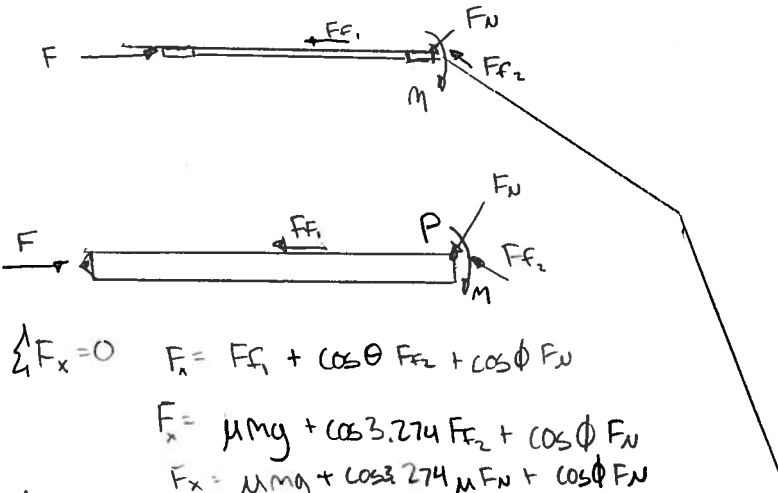
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$$\sum F_x = 0 \quad F_x = F_{F1} + \cos \theta F_{F2} + \cos \phi F_N$$

$$F_x = \mu mg + \cos 3.274 F_{F2} + \cos \phi F_N$$

$$F_x = \mu mg + \cos 3.274 \mu F_N + \cos \phi F_N$$

$$\sum F_y = 0 \quad \sin \theta F_{F2} = \sin \phi F_N$$

$$\sin \theta \mu F_N = \sin \phi F_N$$

$$\sin \theta \mu = \sin \phi$$

$$\sin (3.274) 0.16 = \sin (86.726)$$

$$0.00914 = 0.9984$$

$$0 = 0.98923$$

$$F_{F2} = \mu F_N$$

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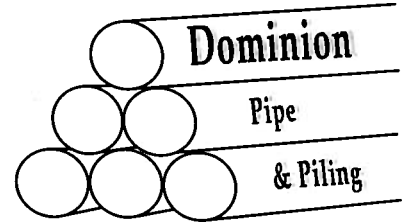
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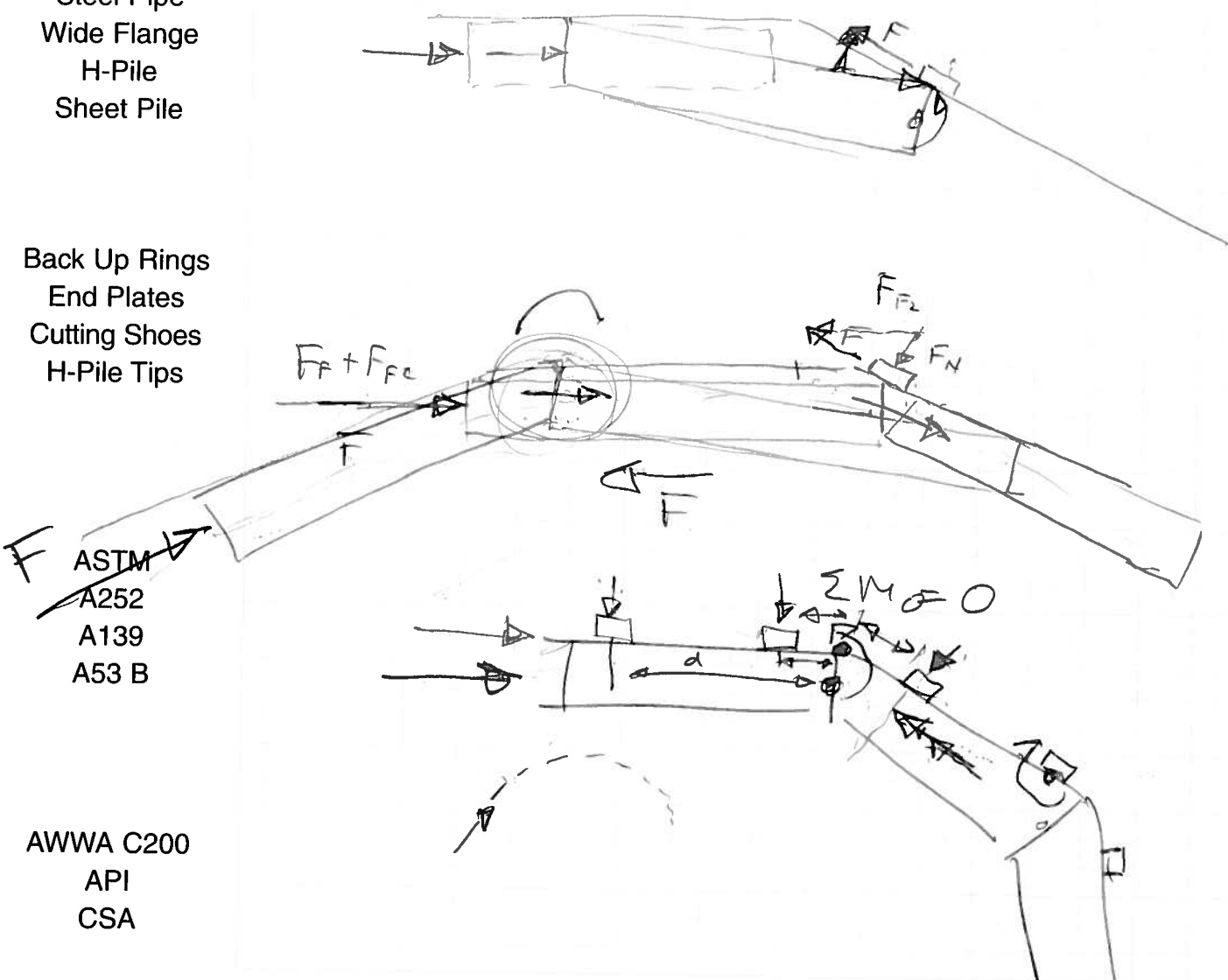
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