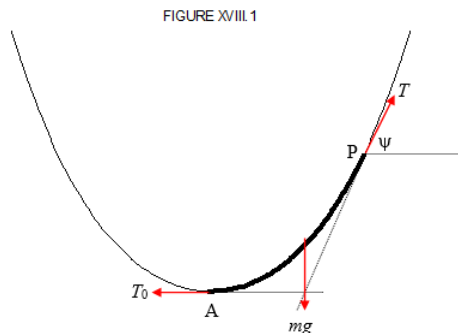


## 18.2: The Intrinsic Equation to the Catenary

We consider the equilibrium of the portion AP of the chain, A being the lowest point of the chain (Figure XVIII.1).



It is in equilibrium under the action of three forces: The horizontal tension  $T_0$  at A; the tension  $T$  at P, which makes an angle  $\psi$  with the horizontal; and the weight of the portion AP. If the mass per unit length of the chain is  $\mu$  and the length of the portion AP is  $s$ , the weight is  $\mu s g$ . It may be noted that these three forces act through a single point.

Clearly,

$$T_0 = T \cos \psi \quad (18.2.1)$$

and

$$\mu s g = T \sin \psi, \quad (18.2.2)$$

from which

$$(\mu s g)^2 + T_0^2 = T^2 \quad (18.2.3)$$

and

$$\tan \psi = \frac{\mu s g}{T_0} \quad (18.2.4)$$

Introduce a constant  $a$  having the dimensions of length defined by

$$a = \frac{T_0}{\mu g}. \quad (18.2.5)$$

Then Equations 18.2.3 and 18.2.4 become

$$T = \mu g \sqrt{s^2 + a^2} \quad (18.2.6)$$

and

$$s = a \tan \psi. \quad (18.2.7)$$

Equation 18.2.7 is the *intrinsic equation* of the catenary.

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