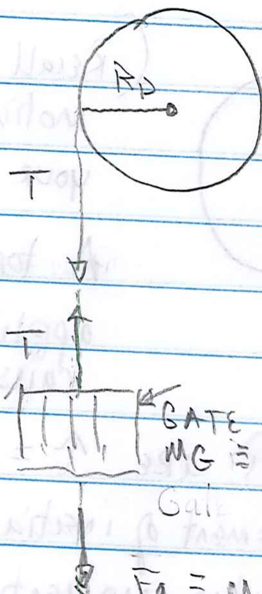
General Physics Lab – Notes/Addendum

Algebraic Solution for finding mass of drum (tutorial)

Remark: This problem is solved in its entirety algebraically. The numbers/constants are substituted following the algebraic development and simplification.



DRUM

M_{DRUM} $(M_D) = ?$

$R_D \equiv$ Radius of Drum

$T \equiv$ tension

GATE

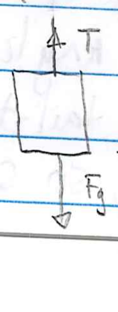
$M_G \equiv$ mass of GATE

$F_g = M_G \cdot g$ g – local gravitational constant

∴ Gate descends with acceleration $a_t = 0.1g$, where $a_t \equiv$ tangential/linear acceleration

Let's break up the problem into 2 parts: part 1 is the gate, part 2 is the drum. We will combine the algebraic calculations from parts 1 & 2 to find the mass of the gate, M_G.

Part 1 – Gate: Newton's 2nd Law



$$F_g - T = M_G a_t$$

$$\Rightarrow M_G g - T = M_G a_t$$

OVER →

Solving for T, we get

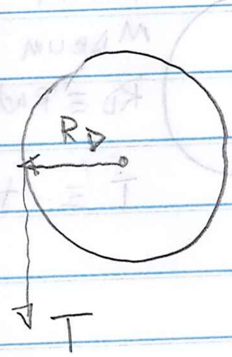
$$T = M_G \cdot g - M_G \cdot a_t = M_G(g - a_t) = M_G(g - 0.1g)$$

$$\boxed{T = M_G(0.9g)}$$

Now we know T as we are given the value for for M_G, and we have a value for g, the local gravitational constant

Let's use T to find the mass of the drum, M_D

Part 2:



(Recall there is no vertical motion of the drum. Refer to your class notes for this.)

A torque, τ, has been applied to the drum, causing it to rotate.

The equation for τ are $\tau = I\alpha = RF\sin\theta$

$I \equiv$ moment of inertia of drum $= \frac{1}{2} M R_D^2$

$\alpha \equiv$ Angular momentum of drum

Note $a_t = \alpha \cdot R_D$ (recall $a_t \equiv$ tangential/linear accelration)

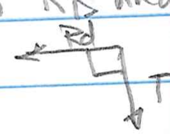
so $\alpha = \frac{a_t}{R_D} = \frac{0.1g}{R_D}$

$F \equiv$ force. In this case, the force applied to the drum causing it to rotate is tension, T.

hence $F = T$

$R \equiv R_D$ (radius of drum

θ is the angle between R_D and T (drawn tail-to-tail)



$\theta = 90^\circ$, so $\sin 90^\circ = 1$

Putting this all together, we have

$$\tau = I_D \alpha = R_D T$$

T

$$= \frac{1}{2} M_D R_D^2 \cdot \frac{a_t}{R_D} = R_D \cdot [M_G (0.9g)]$$

This simplifies to

$$\frac{1}{2} M_D R_D^{\not 2} \cdot \frac{a_t}{\not R_D} = R_D [M_G (0.9g)]$$

Now, we have

$$\frac{1}{2} M_D R_D \cdot a_t = R_D \cdot M_G (0.9g)$$

We want to isolate M_D so that we can solve for M_D. Notice that M_D is being multiplid by $\frac{1}{2} \cdot R_D \cdot a_t$

Let's multiply both sides of our equation through by 1/2, and the reciprocals of R_D and a_t (alternatively, you can divide both sides of the equation through by $\frac{1}{2} \cdot R_D \cdot a_t$)

This gives us

$$\frac{\frac{1}{2} M_D R_D \cdot a_t}{\frac{1}{2} R_D \cdot a_t} = \frac{M_G R_D \cdot 0.9g}{\frac{1}{2} R_D \cdot a_t}$$

Recall $\frac{1}{\frac{1}{2}} = 2$, so

$$M_D = \frac{2(0.9g)}{a_t} = \frac{2(0.9g) M_G}{0.1g}$$

OVER →

continued

$$m_D = \frac{2(0.9)}{0.1} m_G$$

$$m_D = 18 \cdot 47 \text{ kg}$$

$$m_D = 846 \text{ kg}$$ (a little less than 2 tons)