Chap 4 HW

30/ $\vec{a} = \text{constant} = a_x \hat{i} + a_y \hat{j}$

At $t=0$, $\vec{v} = (10\hat{i} + 20\hat{j})$ m/s

$t=4$, $\vec{v} = 10\hat{j}$ m/s

a) $V_x = V_{x0} + a_x t$, $v_{x0} = 10$, $v_x(t=4) = 0$,

$a_x = -2.5$ m/s^2

$V_y = V_{y0} + a_y t$, $a_y = -2.5$ m/s^2

so $\vec{a} = (-2.5\hat{i} - 2.5\hat{j})$ m/s^2

b) $x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2 \Rightarrow$ If starting at origin $x = (10\,m/s)t - (1.25\,m/s^2)t^2$

$V_x = 10\,m/s - (2.5\,m/s^2)t$

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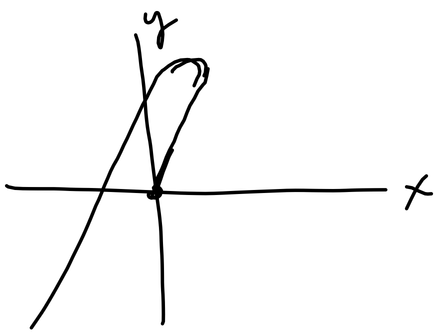
$x = (10\,m/s)t - (1.25\,m/s^2)t^2$

$y = (20\,m/s)t - (1.25\,m/s^2)t^2$



I clicker question

We want to compare f_k in case (i) and (ii)

$f_k = \mu_k N$, if μ_k is same in both cases,

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Then we just need to compare N in both cases

(i) $N_i = mg$

(ii) $N_{ii} = mg\cos\theta$

Now $\cos\theta \leq 1$

Thus, $N_i \geq N_{ii}$ (equal when $\theta = 0$)

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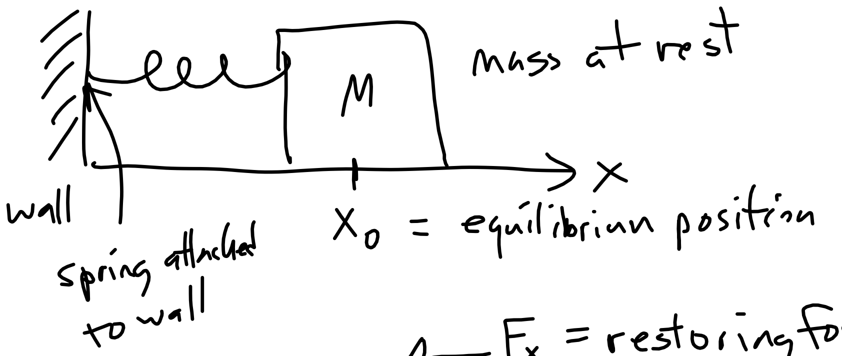
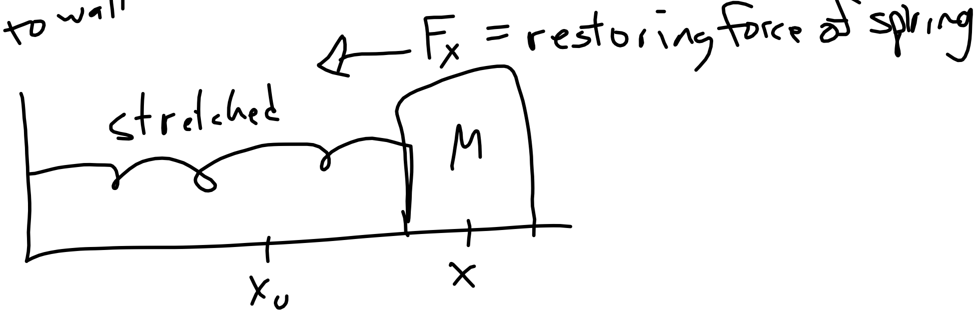
Hooke's Law





Hooke's law: $F_x = -k(x - x_0)$

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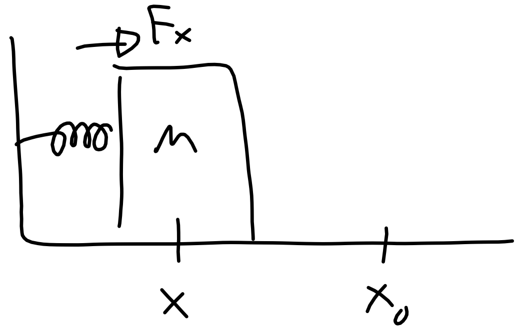

$$F_x = -k(x - x_0)$$

What is k? Spring constant. Units for k should be $\frac{\text{force}}{\text{displacement}} \rightarrow \frac{N}{m}$. But $N = \frac{kg \cdot m}{s^2}$

So we could write k in units of $\frac{kg}{s^2}$

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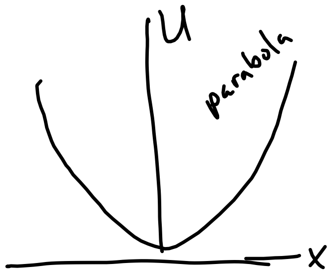
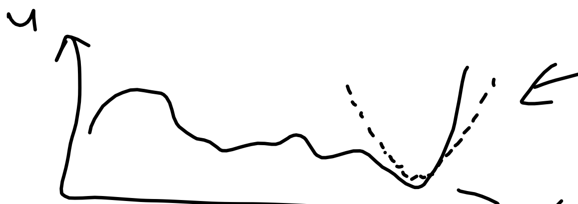
Looking ahead, we can talk about simple harmonic motion (oscillations in a spring-mass system). We'll find that $\omega = \sqrt{\frac{k}{m}}$

Also, we're going to define potential energy, and we'll find $U = \frac{1}{2}k(x - x_0)^2$



If we have complicated $U(x)$



← We can approximate certain points on $U(x)$ with a parabola, and use all of our spring tools.

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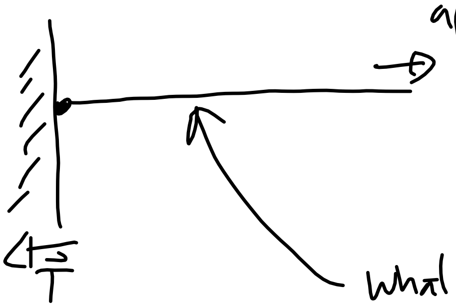
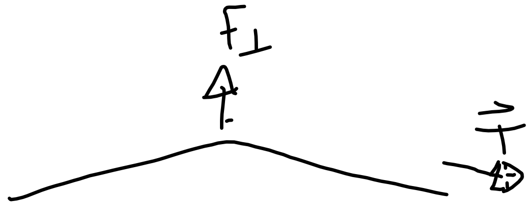
More on tension

If we have a rope that's tied on one end apply a tension force $\vec{T}$



What if we apply a $\perp$ force at the middle?

Example



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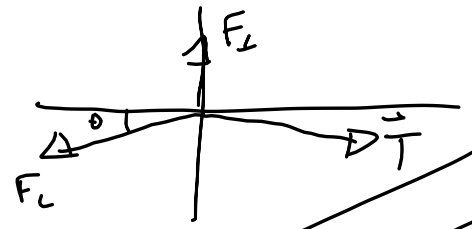
FBD for rope



$$\Sigma F_x = 0$$

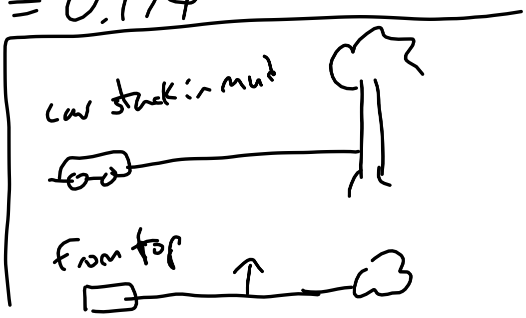
$$F_y = 0$$

$$T\cos\theta - F_L\cos\theta = 0$$

$$F_\perp = T\sin\theta + F_L\sin\theta = 2T\sin\theta$$

If $\theta = 5^\circ$, $2\sin\theta = 0.174$

$$T = \frac{F_\perp}{0.174} \approx 5F_\perp$$



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Air drag is really under the topic of fluid resistance

We have regimes:

I low speed (or high viscosity) $f = kv$

where k is a "constant"

II high speed (or low viscosity) $f = Dv^2$

where D is a "constant"

Both k and D depend on size + shape of object,

<u>and</u> fluid density + viscosity.

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Note for falling bodies, in case II

if velocity is a constant,

$a = 0$, then v = terminal velocity

$f = mg$

$Dv_t^2 = mg$

$$\boxed{v_t = \sqrt{\frac{mg}{D}}}$$

Example: Hailstone falling through air

For radius $\approx 3\,cm$, $m = 100g = 0.1\,kg$

we find $D = 10^{-3}\,kg/m$, $v_t = \sqrt{\frac{(0.1\,kg)(9.8\,m/s^2)}{10^{-3}\,kg/m}} = 32\,m/s$

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