Lecture 12

4 Kasım 2019 Pazartesi 10:38

Midterm I : Saturday, 9th of Nov. @ 10:00

Chapter 1 → Chapter 6

90 minutes with 15% impact on grade

Rooms: EB-101, 103, 104

Altuntaş-Dilsiz, Doğan-Kuzgun, Oğuz-Yücel

What did we learn so far?

Chapter 1

Units → Units & Standards

- → length | meter, c
- → time | second
- → mass | kilogram, Planck's const.

SI

Uncertainty & Significant figures

Accuracy → 2.9 10^8 m/s

Precision → 2.85425 10^8 m/s

2.99792458 10^8 m/s

Significant figures:

multiply / divide: fewest significant figures

$$\underset{4}{2.572\ m/s} \cdot \underset{2}{5.2\ s} = (\quad)$$

addition / subtraction: fewest digits to the right of the decimal point

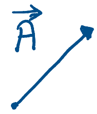
$$5.742\ m/s + 2.1\ m/s = 7.8\ m/s$$

Vectors

$\vec{A}$

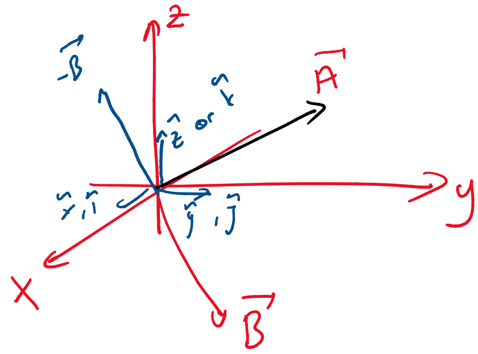
Vectors

↳ magnitude, direction



Cartesian coordinates: $\vec{A} = A_x\hat{x} + A_y\hat{y} + A_z\hat{z}$

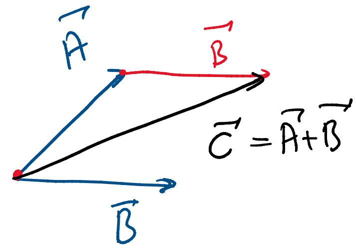
$\hat{x} = \hat{\imath}, \quad \hat{y} = \hat{\jmath}, \quad \hat{z} = \hat{k}$



$$\vec{A} + \vec{B} = \vec{B} + \vec{A} = \vec{C}$$

$$\vec{A} - \vec{B} = \vec{A} + \underbrace{(-\vec{B})}_{}$$

flipping the direction of the vector.

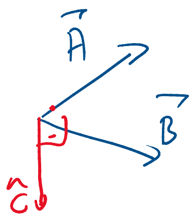


⇒ Products of vectors: $\vec{A}\cdot\vec{B} = AB\cos\theta$

Scalar product (dot)

angle between the vectors

$$W = \vec{F}\cdot\vec{s}$$



$$\vec{A} \times \vec{B} = \hat{c}\,(AB\sin\theta)$$

vector product (cross)

$\hat{c} \perp \vec{A}, \vec{B}$

$$\vec{B} \times \vec{A} \neq \vec{A} \times \vec{B}$$

$$(A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}) \cdot (B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}) =$$

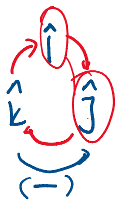
$\hat{\imath}\cdot\hat{\jmath} = 0$

$\hat{\imath}\cdot\hat{k} = 0$

$$= A_xB_x + A_yB_y + A_zB_z$$

$$(A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}) \times (B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}) =$$

$$(A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}) \times (B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}) =$$



$$= \hat{\imath}(A_y B_z - A_z B_y) + \hat{\jmath}(A_z B_x - A_x B_z) + \hat{k}(A_x B_y - A_y B_x)$$

$$(\vec{D} \times \vec{C})(\underbrace{\vec{A}\cdot\vec{B}}_{\#}) = \vec{D} = \#\vec{C}$$

$$\vec{A}\cdot(\underbrace{\vec{C}\times\vec{B}}_{\vec{D}}) = \#$$

→ Learn how to deal with significant figures

&

How to work with vectors → components
→ products.

Chapter 2 - Motion along a straight line

vector quantities

Displacement	$\vec{r}$	$\vec{r} = \vec{r}_0 + \int_{t_0}^{t_f} \vec{v}\,dt$
↓ Velocity	$\vec{v} = \frac{d\vec{r}}{dt}$	$\vec{v} = \vec{v}_0 + \int_{t_0}^{t_f} \vec{a}\,dt$
↓ Acceleration	$\vec{a} = \frac{d^2\vec{r}}{dt^2} = \frac{d\vec{v}}{dt}$	

a special case: motion with constant acceleration:

motion on earth

$$\boxed{x(t) = x_0 + v_0 t + \frac{1}{2} a t^2}, \quad \boxed{v_x = v_0 + a_x t}$$

$$\boxed{v_x^2 = v_0^2 + 2a_x(x - x_0)}$$

$$\boxed{V_x^2 = V_0^2 + 2a_x(x - x_0)}$$

Hint for the Midterm: Make sure that you understand the above formulae

Basis of free-fall problems

Chapter 3 – Motion in two or three dimensions

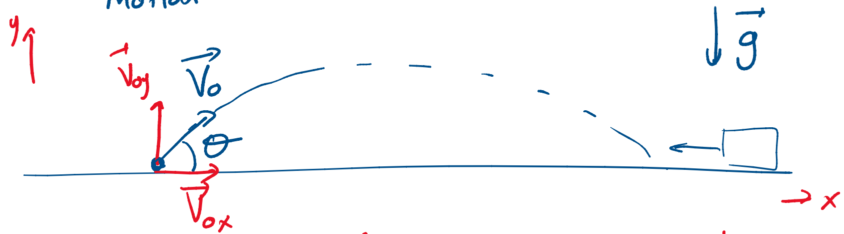
displacement $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

$$\frac{d\vec{r}}{dt} = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j} + \frac{dz}{dt}\hat{k} = \vec{V_x} + \vec{V_y} + \vec{V_z}$$

$$\frac{d^2\vec{r}}{dt^2}$$

⇒ Projectile motion:

a constant $\vec{a}$ motion



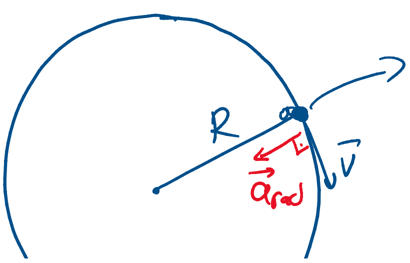
$y = (V_0 \sin\theta)t - \frac{1}{2}gt^2$

$x = V_0 \cos\theta . t$

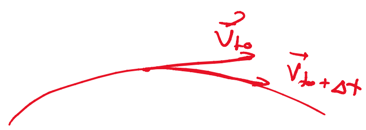
$V_y = V_0 \sin\theta - gt$

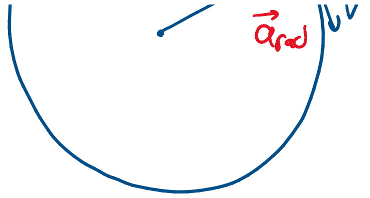
$V_x = V_0 \cos\theta$

⇒ Circular Motion



speed of the object is constant!



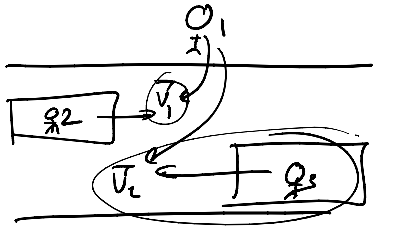


$$\frac{\vec{V}_{t_0+\Delta t} - \vec{V}_0}{\Delta t} = \vec{a}_{rad}$$

⇒ Relative motion

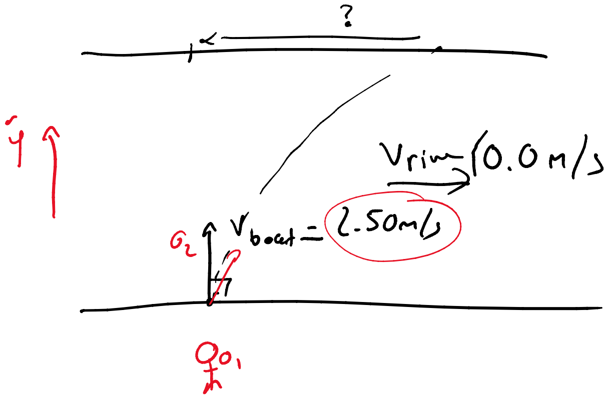
↳ Gallilean relativity

→ Problems will involve rivers and wind for airplanes



O_3 wrt O_2 $\vec{V}_2$ $\vec{V}_1$

$|\vec{V}_2| + |\vec{V}_1|$

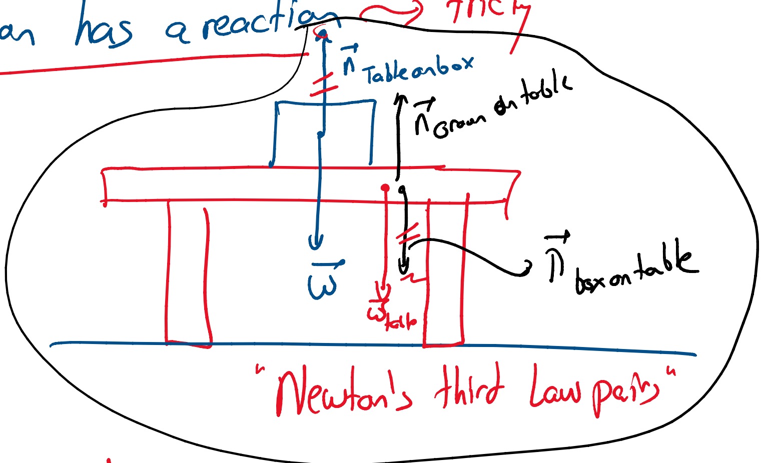


Chapter 4: Newton's Laws of Motion

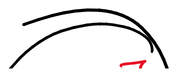
1.) Inertia

2.) $\vec{F} = m\vec{a}$ → reason why things move

3.) Every action has a reaction → tricky



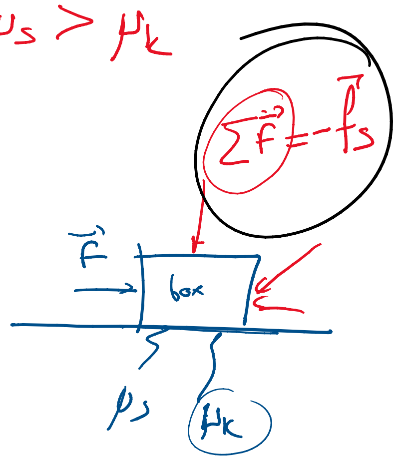
> Friction forces → μ_k & μ_s → $\mu_s > \mu_k$

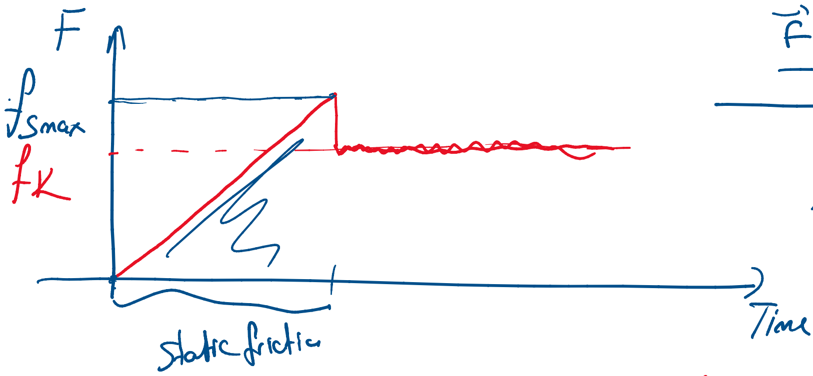


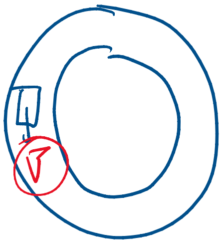
> Friction forces → μ_k & μ_s → $\mu_s > \mu_k$

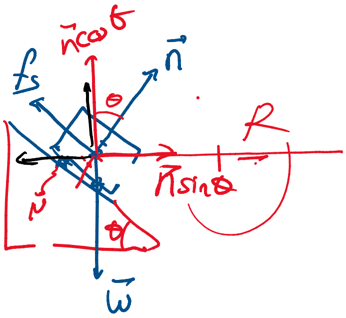
μ_k ↓ Kinetic

μ_s ↓ static friction









$$w = n\cos\theta$$

$$f_s \sin\theta + n\cos\theta = w$$

$$m\frac{v^2}{R}$$

$$-\underbrace{f_s}_{\mu_s n}\cos\theta + n\sin\theta = m\frac{v^2}{R}$$

$$(\mu_s \sin\theta + \cos\theta)\,n = w$$

$$(\sin\theta - \mu_s\cos\theta)\,n = \frac{mv^2}{R}$$

$$\frac{\sin\theta - \mu_s\cos\theta}{\mu_s\sin\theta + \cos\theta}\,\cancel{m}g = \frac{\cancel{m}v^2}{R}$$

$$\boxed{\frac{\sin\theta - \mu_s\cos\theta}{\mu_s\sin\theta + \cos\theta}\,Rg = v}$$

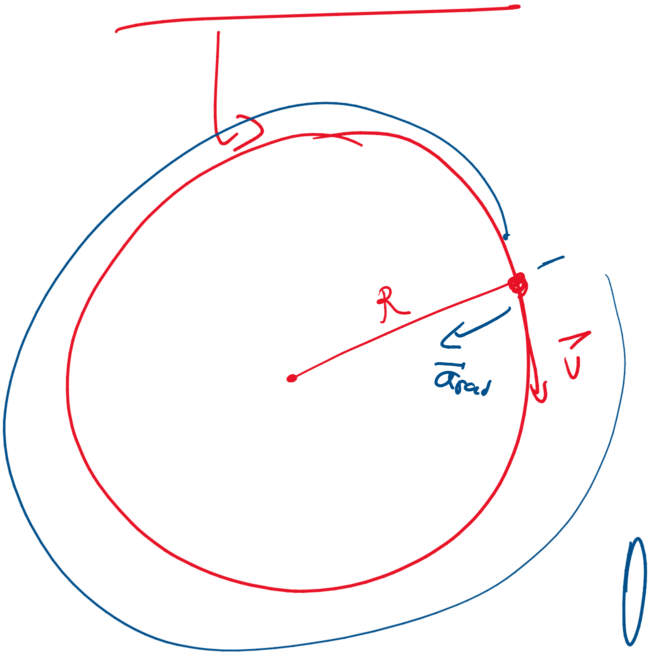
$$\frac{\tan\theta - \mu_s}{\mu_s\tan\theta + 1}\,Rg = v^2$$

Fluid resistance: $f = kv$ → "low" speed

Fluid resistance: $f = kv \rightarrow$ low speed

$f = Dv^2 \rightarrow$ "high" speed

↳ Circular motion + (friction)

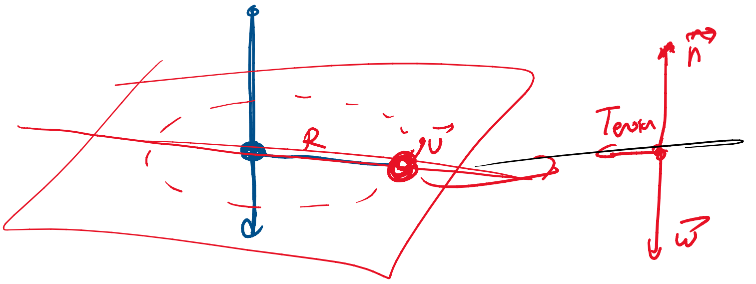


$$a_{rad} = \frac{v^2}{R} \quad , \quad T = \frac{2\pi R}{v}$$

$$a_{rad} = \frac{4\pi^2 R}{T^2}$$

$$\boxed{\omega . R = v} \qquad \boxed{a = \omega^2 R}$$

! Sum of all forces must be equal to $m\vec{a}_{rad}$!



$$T_{ension} = \frac{mv^2}{R}$$

Chapter 6: Work & Kinetic Energy:

$$W_{12} = \int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{s} \qquad W_{12} = \Delta K = \frac{1}{2} m(v_2^2 - v_1^2)$$

Change in Kinetic energy

"Joules"

Always be aware of who does the

"Joules"

$$kg \, m^2/s^2$$

Always be aware of who does the work?

What force?

(−) work

↳ Power → rate of change of Work in time

$$P = \frac{dW}{dt} \rightarrow \text{Units in Watts}$$

$$= \frac{d}{dt}(\vec{F} \cdot \vec{s}) = \vec{F} \cdot \underbrace{\frac{d\vec{s}}{dt}}_{\vec{v}} = \vec{F} \cdot \vec{v}$$