Physics 113 - October 10, 2006

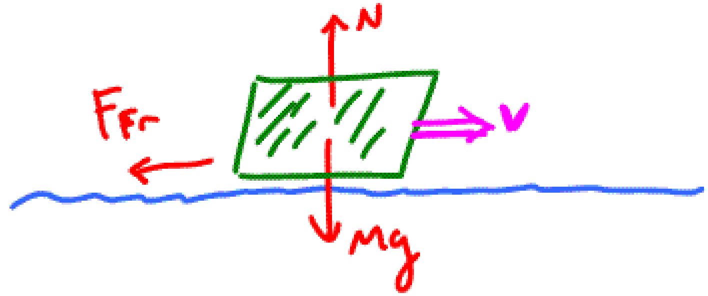
Work and Energy

- Exam to be handed back Thursday hopefully
- P113 project

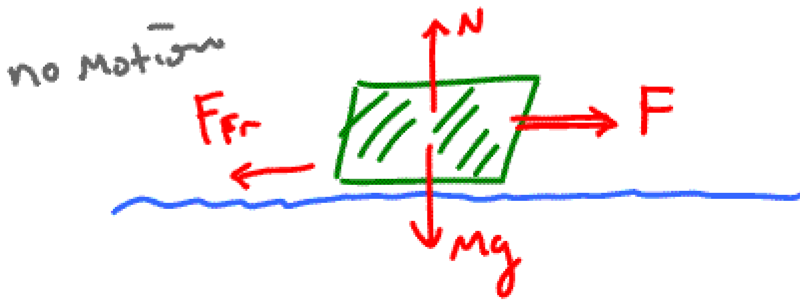
  Sat. Dec 2 - posters

  Dec 5, 7 lectures - in class presentations

Last Time → Friction



$$F_{Fr} = \mu_k N$$



$$F_{Fr} \le \mu_s N$$

does not have to be horizontal

limiting value

Bicycle brakes for example

Work + Energy

(Force) × (Distance) ~ work

Energy ~ Ability to do work

↳ different form

mechanical energy
Kinetic Energy
Mass $E = mc^2$
light
Sound
heat etc.

Potential Energy

Energy ≡ Work   mks Joule

$$\text{Joule} = Nm = kg\frac{m}{s^2}\,m = kg\frac{m^2}{s^2}$$

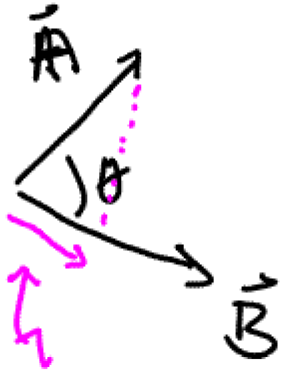
In Physics

work done by force on an object

= Force × distance thru which object is moved along line of the force

– OR –

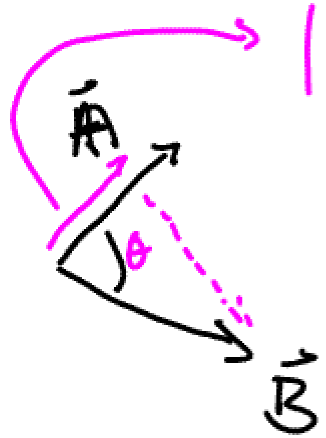
= Magnitude of component of force along direction of movement × (distance moved)



$$|\vec{B}||\vec{A}_{\text{along } \vec{B}}|$$

$$|\vec{A}||\vec{B}|\cos\theta$$

$$|\vec{A}_{\text{Along } \vec{B}}| = |\vec{A}|\cos\theta$$



$$|\vec{B}_{\text{Along } \vec{A}}| = |\vec{B}|\cos\theta$$

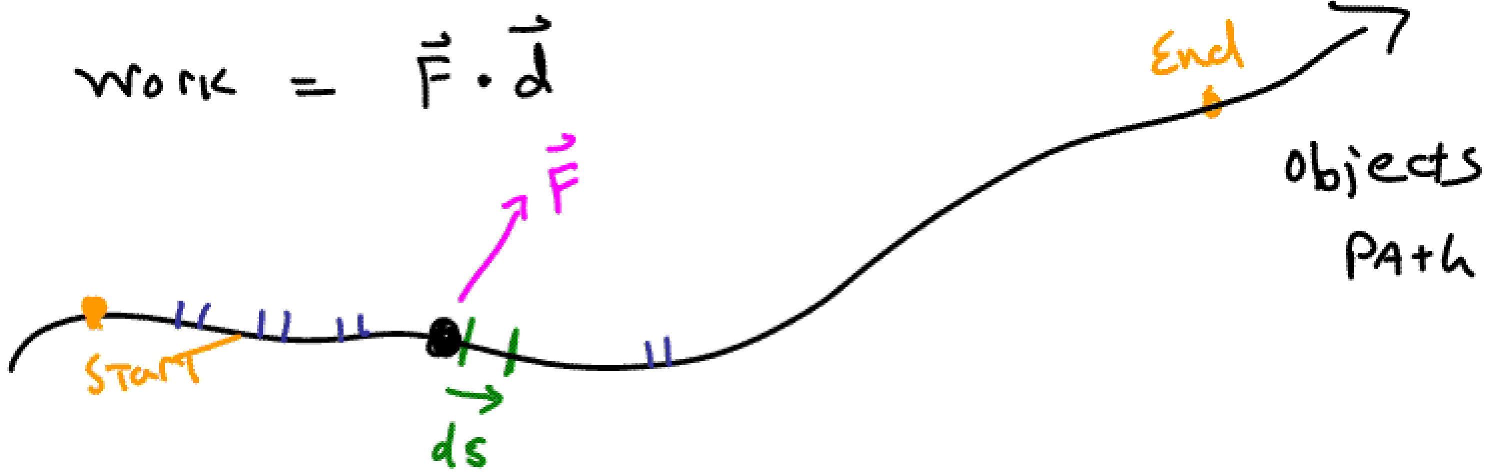
$$|\vec{A}||\vec{B}|\cos\theta$$

dot Product (vector multiplication)

Scalar product

$$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$$

$$\text{Work} = \vec{F} \cdot \vec{d}$$



$$dW = \vec{F} \cdot d\vec{s}$$

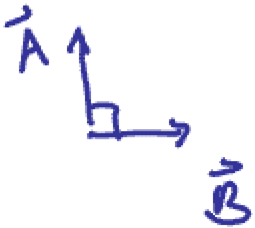
$$W = \int_{\text{start}}^{\text{end}} \vec{F} \cdot d\vec{s}$$

More on Scalar product

vectors

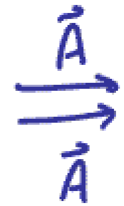
Scalar

$$\vec{A} \cdot \vec{B} = |\vec{A}||\vec{B}|\cos\theta = A_x B_x + A_y B_y + A_z B_z$$



$$\vec{A} \cdot \vec{B} = 0$$

$$|\vec{A}||\vec{B}|$$



$$|\vec{A}|^2$$

$$\hat{i} \cdot \hat{i} = |\hat{i}||\hat{i}| = 1$$

$$\hat{i} \cdot \hat{j} = 0$$

Prove $\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$

$$\vec{A}\cdot\vec{B} = (A_x\hat{i} + A_y\hat{j} + A_z\hat{k})\cdot(B_x\hat{i} + B_y\hat{j} + B_z\hat{k})$$

$$= A_xB_x\,\hat{i}\cdot\hat{i} + A_xB_y\,\hat{i}\cdot\hat{j} + A_xB_z\,\hat{i}\cdot\hat{k}$$
$$+ A_yB_x\,\hat{j}\cdot\hat{i} + A_yB_y\,\hat{j}\cdot\hat{j} + A_yB_z\,\hat{j}\cdot\hat{k}$$
$$+ A_zB_x\,\hat{k}\cdot\hat{i} + A_zB_y\,\hat{k}\cdot\hat{j} + A_zB_z\,\hat{k}\cdot\hat{k}$$

(orange) Terms → 0 because unit vectors ⊥ to each other → dot product = 0

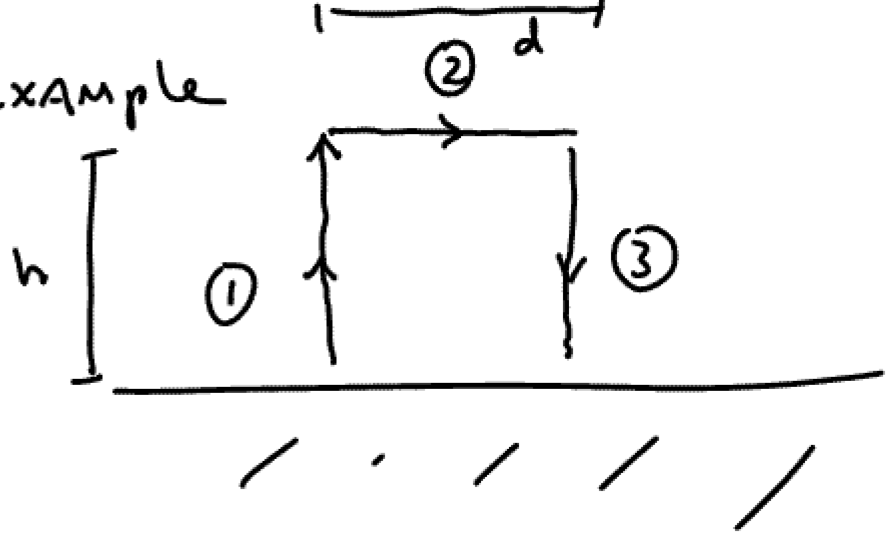
(magenta) = 1 $\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1$

$$\therefore \quad \vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z$$

useful formula

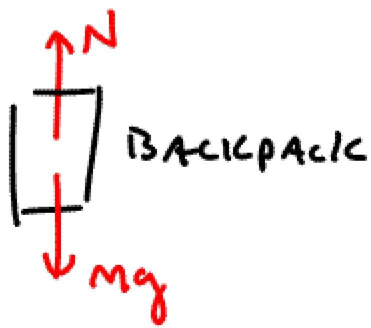
No ... I will not ask you to do vector proofs like this on an exam

Example



What is work done by climber on BACKPACK?

$a_y = 0$



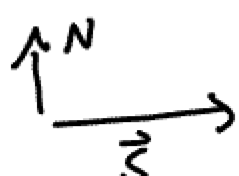
$N = mg$

①

$|\vec{s}| = h$

$\text{Work} = Nh = mgh$

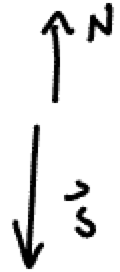
②



$|\vec{s}| = d$

$\text{Work} = 0$

③



Work $= \vec{N} \cdot \vec{S} = -Nh = -mgh$

TOTAL WORK $= W_{①} + W_{②} + W_{③} = mgh + 0 + (-mgh)$

$= 0$

Net change in height is zero

Gravitation is a <u>conservative</u> force ... Meaning

The change in the energy of a system

as something moves from A to B is

Path independent

We'll talk much more about conservative forces ...