Lecture 11

31 Ekim 2019 Perşembe 09:39

→ Midterm I – 9th of Nov. | 10:00 am

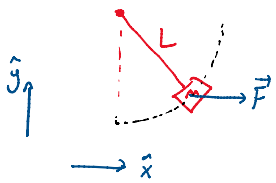
Work & Kinetic Energy

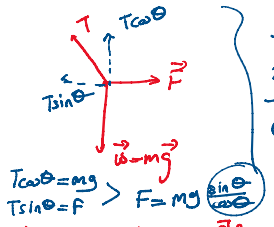
Work: $dW = \vec{F} \cdot d\vec{s}$ $\Rightarrow$ $W_{12} = \int_1^2 \vec{F} \cdot d\vec{s} = \Delta K$

Change in Kinetic Energy

> Always ask: who does the work?

Ex!





$T\cos\theta = mg$

$T\sin\theta = F$ $\Rightarrow$ $F = mg\frac{\sin\theta}{\cos\theta}$

Sum of all force ≈ 0

Quasi-Static motion $\Rightarrow$ $\Delta K \approx 0$

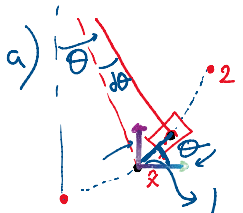
a) Work done by $\vec{F}$?

b) Work done by $\vec{T}$?

c) Work done by $\vec{w}$?

d) $\sum$ Work ?

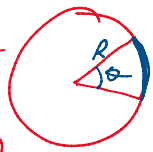
a)



$L \cdot d\theta = |d\vec{s}|$

$W = \int_1^2 \vec{F} \cdot d\vec{s}$

$L_{arc} = R \cdot \theta$



$\theta \to 0$

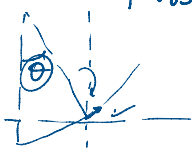
$d\theta$

$\sin d\theta \approx d\theta$

$\sin\theta = \theta - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} + \cdots$

$\vec{F} \cdot d\vec{s} = F\hat{x} \cdot d\vec{s}$

$(ds\cos\theta\,\hat{x} + ds\sin\theta\,\hat{y})$



$= F\,ds\cos\theta$

$L\,d\theta$

$dW = F \cdot L \cdot \cos\theta \cdot d\theta$

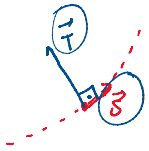
$mg\frac{\sin\theta}{\cos\theta}$

$= mgL\sin\theta\,d\theta$

$$W_f = \int_{\theta=0}^{\theta_f} mgL\sin\theta\,d\theta = mgL\left(-\cos\theta\Big|_0^{\theta_f}\right)$$

$$= mgL\left(1 - \cos\theta_f\right)$$

b) Work done by $\vec{T}$? $\quad W_T = 0$



$\vec{T} \cdot d\vec{s} = ?_{\circ} = 0$

$\vec{T} \perp d\vec{s}$

c) Work done by $\vec{w}$?

$\vec{w} \cdot d\vec{s} = (-\hat{y}\, mg) \cdot (L d\theta \cos\theta \hat{x} + L d\theta \sin\theta \hat{y})$

$= -mgL \sin\theta \, d\theta$

$$W_w = \int_0^{\theta_f} -mgL\sin\theta \, d\theta$$

$$= -mgL(1-\cos\theta_f)$$

d) $W_{Total} = W_F + W_T + W_w = 0$

W_w → (−) work

Power: Rate at which the work is done:

$$\frac{dW}{dt} = P$$ → Units are Watt

Watt → $\frac{\text{Joules}}{\text{second}} \equiv kgm^2/s^3$

Horsepower: HP → James Watt

5 ¢ (kWh) Energy

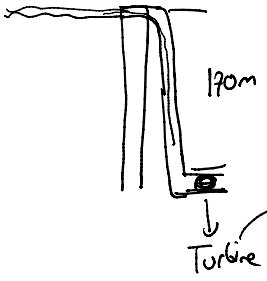
Amount of work done by a horse in a minute:

$1\,hp = 33000\,lb/60s = 746\,W$

Ex 6.86

Ex | 6.86

Power by a dam: 2000 MW
10^6 W



92%

Turbine → Electricity → 2000 MW

How many m^3/s water must flow from the top of the dam?

$$2000\,MW \times \frac{100}{92} = 2174\,MW$$

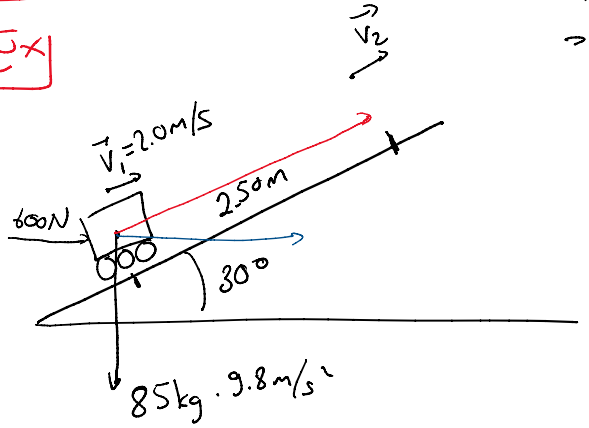
$$1\,m^3 \Rightarrow 1000\,kg \qquad \frac{g \cdot s}{9.8\,m/s^2 \cdot 170\,m} = 2174\,MW \cdot s$$

m/s

$$\frac{\frac{mass}{s}}{1000\,kg} = \frac{2174\,MW}{9.8\,m/s^2 \cdot 170\,m} = \dots$$

$$1279\ m^3/s$$

Ex

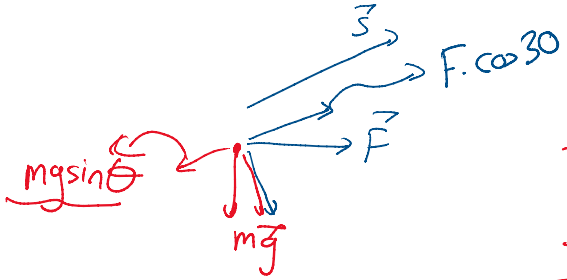


→ V_2=?

→ Work done by "600N"?

$$W = \Delta K = \frac{1}{2} 85\,kg \cdot \left(V_2^2 - (2.0)^2_{m/s}\right)$$

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



$$F\cos 30 - mg\sin\theta$$

$$= 103\,N$$

$$103\,N \cdot \dots \qquad 1.85\,kg \left(\dots^2 - (2.0\,m/s)^2\right)$$

$mg = 103N$

$103N \cdot 2.50m = \frac{1}{2} 85kg \cdot (v_2^2 - (2.0m/s)^2)$

$v_2 = 3.17 m/s$

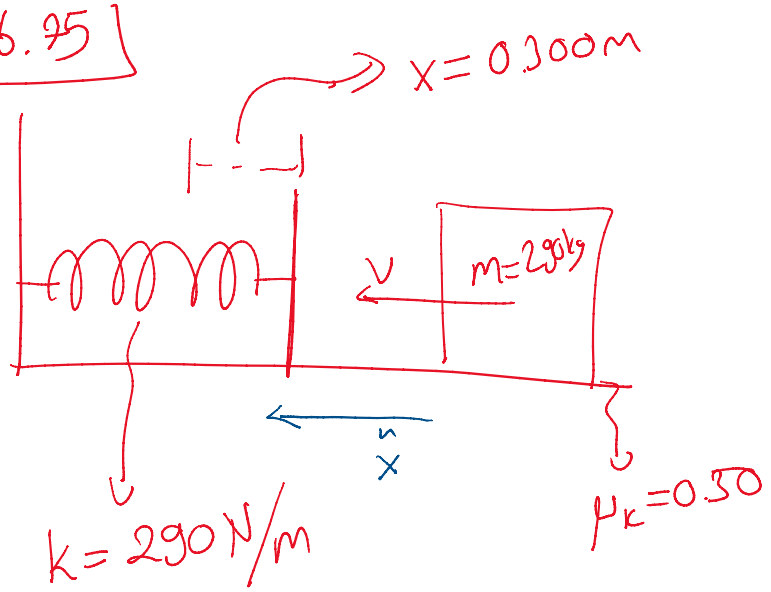
$W_f = F \cdot \cos 30 \cdot s$

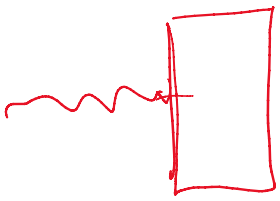
ma

$v_2^2 = v_1^2 + 2as$

3.17 m/s

Ex 6.25





$\Delta K = W$

$\left(0 - \frac{1}{2} m v^2\right) = -\int_0^{0.300m} (F_{spring} + F_{friction}) \cdot ds$

$F_{spring} \rightarrow kx$

$F_{friction} \rightarrow mg\mu_K$

$= \frac{1}{2} 290 N/m \, x^2 \Big|_0^{0.300m} + 8.53 x \Big|_0^{0.3m}$

$V = 2.69 m/s$