Seating for PHYS 1020 Midterm
Thursday, October 22
7 - 9 pm

Seating is by last name

Room	From	To
111 Armes	A	BJ
200 Armes	BL	GA
201 Armes	GH	KH
204 Armes	KI	OB
205 Armes	OK	SA
208 Armes	SC	Z

20 multiple choice questions, ch 1-5. Formula sheet provided.

WileyPLUS Assignment 2

Due Monday, October 19 at 11:00 pm
Chapters 4 & 5

Next Week:

Next Wednesday and maybe part of Monday

Review of ch 1 - 5 for the midterm

Email me questions from old exams (back of lab manual), from the book, or WileyPLUS !

Conservation of Mechanical Energy

Mechanical energy = KE + PE = $mv^2/2 + mgy$

In the absence of applied forces and friction:

(change in KE) + (change in PE) = 0

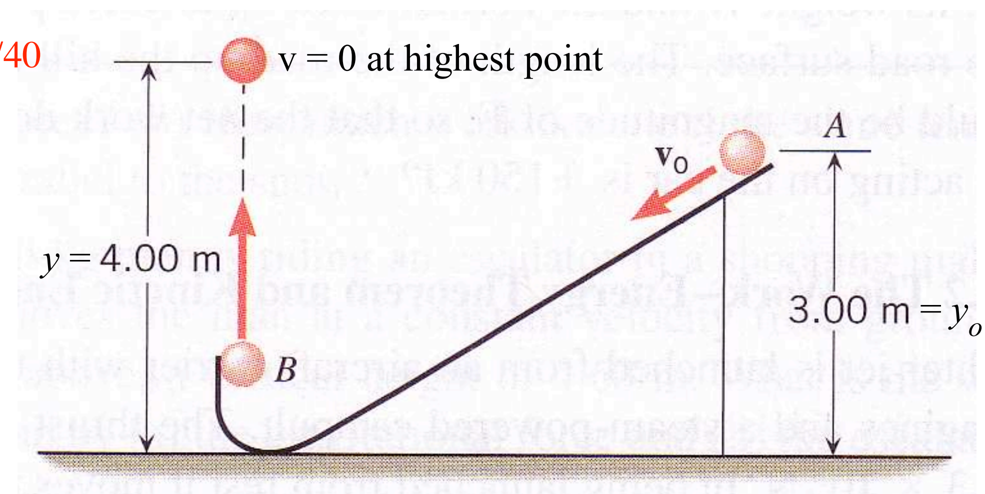
so mechanical energy is conserved.

KE + PE = constant

When an applied force does work, the **work-energy theorem** becomes:

W = ΔKE + ΔPE

6.-/40



Find the speed of the particle at A (v_o). **There is no friction.**

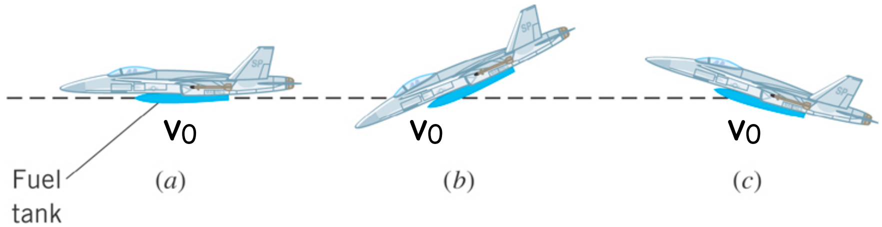
Conservation of mechanical energy: E = KE + PE = constant

At A: $E = mv_0^2/2 + mgy_0 = mv_0^2/2 + 3mg$

At highest point: $E = KE + mgy = 0 + 4mg$

$\rightarrow E = \frac{1}{2}mv_0^2 + 3mg = 4mg \qquad \rightarrow v_0 = \sqrt{2g} = 4.43 \text{ m/s}$

Clickers!

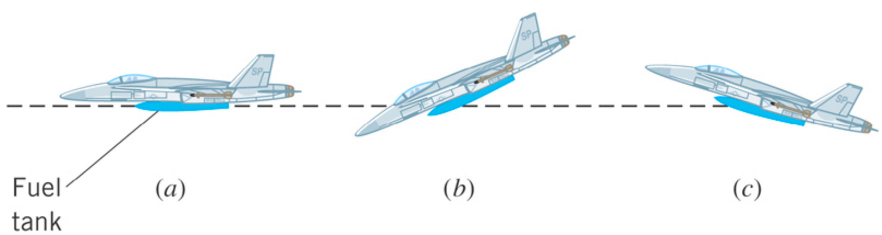


An empty fuel tank is released by three different planes. At the moment of release, each plane has the same speed and each tank is at the same height above the ground.

In the absence of air resistance, do the tanks have different speeds when they hit the ground?

A) The tank in (b) has the highest speed when it hits the ground.
B) The tank in (c) has the highest speed as it reaches a greater height before falling.
C) All three tanks hit the ground at the same speed.

Clickers!



An empty fuel tank is released by three different planes. At the moment of release, each plane has the same speed and each tank is at the same height above the ground.

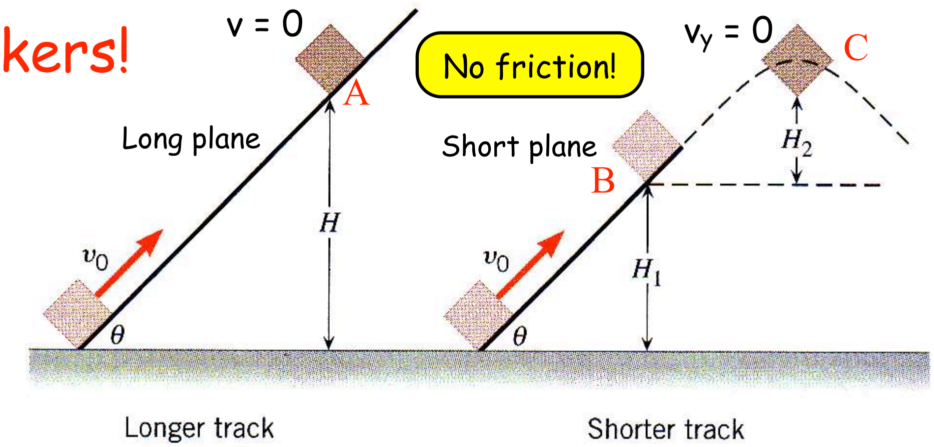
In the absence of air resistance, do the tanks have different speeds when they hit the ground?

On release   As tank hits the ground

Mechanical energy: $KE_A + PE_A = KE_B + PE_B$

The tanks start with the same KE and PE, and when they reach the ground they have the same PE (zero), and so they have the same kinetic energy too.

Clickers!



Initial mechanical energy the same for the two blocks.

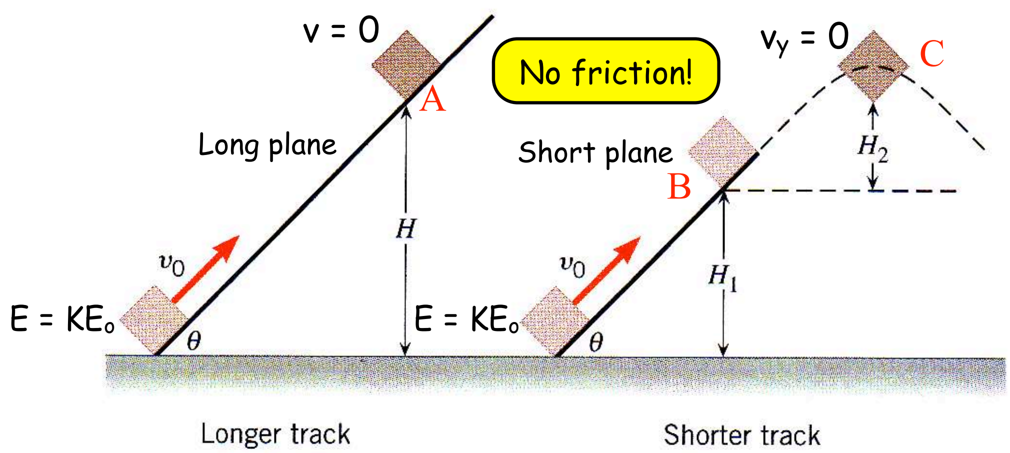
Block at left reaches highest point on plane at A, at y = H.

Block at right leaves shorter plane at B, at $y = H_1$
flies through air to highest point at C, at $y = H_1 + H_2$.

A) A is higher than C

B) A is lower than C

C) A and C are at the same height



A) A is higher than C -

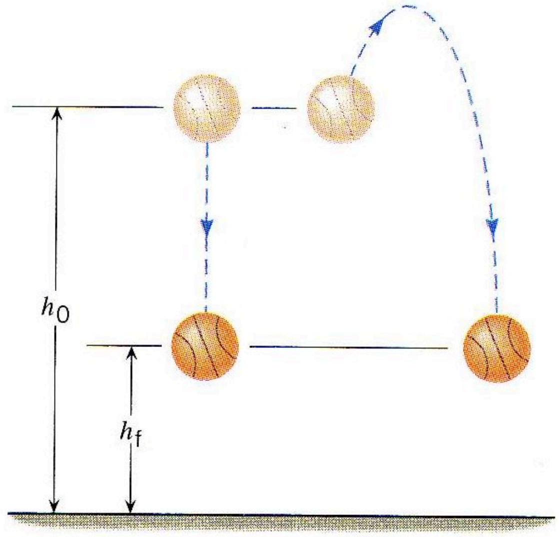
All of the mechanical energy of left block is converted into potential energy at point A:

$E = KE_o = mgH$,

whereas block at right is still moving at highest point:

$E = KE_o = mg(H_1 + H_2) + KE_C$, so $H = (H_1 + H_2) + KE_C/mg$

Conservative Forces



Gravitational potential energy depends only on height

The difference in PE, $mg(h_o - h_f)$ is **independent of path taken**

→ Gravity is a "conservative force"

Conservative Forces

Alternative definitions of conservative forces:

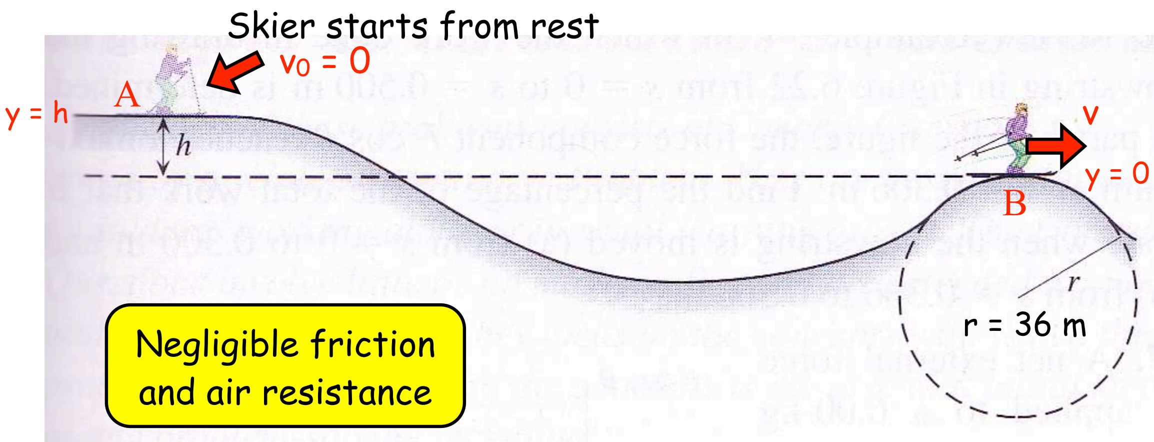
- **The work done by a conservative force in moving an object is independent of the path taken.**
  (Compare pushing a crate across the floor – the most direct path requires the least work. Friction is **not** a conservative force).

- ***A* force is conservative when it does no net work in moving an object around a closed path, ending up where it started.**

In either case, the potential energy due to a conservative force depends only on position.

Examples of conservative forces:

- Gravity, elastic spring force, electric force



6.47/42: What must be the height h if the skier just loses contact with the snow at the crest of the second hill at B?

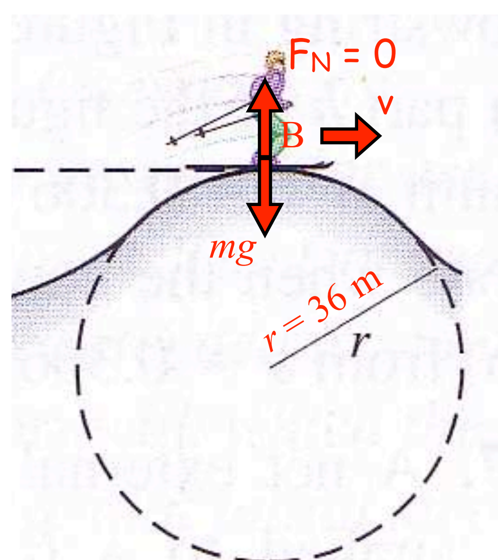
Mechanical energy is conserved, so $E_A = E_B$.

At A At B

That is, $0 + mgh = mv^2/2 + 0$

So, $v^2 = 2gh$, independent of the shape of the dip

$\boxed{v^2 = 2gh}$



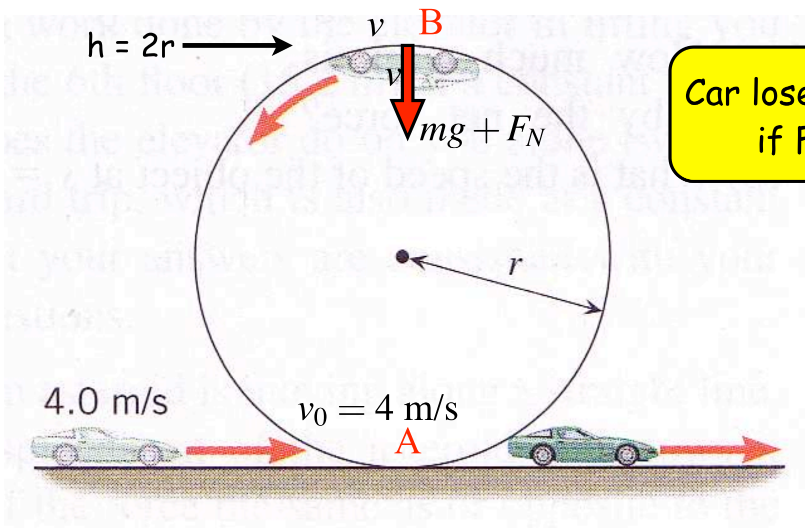
Centripetal force at crest of hill !

If skier loses contact with snow at B, then $F_N = 0$

So, centripetal acceleration toward centre of curved slope is provided only by the skier's weight, mg.

That is, $mg = mv^2/r$ and $\boxed{v^2 = rg}$

So $\boxed{v^2 = rg = 2gh,}$ and $h = r/2 = 18$ m



Car loses contact if $F_N = 0$

6.49/78: Initial speed of model car = 4 m/s. What is maximum radius, r, if the car is to remain in contact with the circular track? No friction.

Conservation of mechanical energy: $E_A = E_B$

Or, $KE_A + PE_A = KE_B + PE_B$ That is, $\frac{1}{2}mv_0^2 + 0 = \frac{1}{2}mv^2 + mgh$

and $h = 2r$

Non-conservative Forces

The work done by a non-conservative force depends on the path taken (as in pushing a crate across the floor...).

The longer the path taken, the more the (negative) work is done by the friction force.

A potential can be defined only for a conservative force.

Examples of non-conservative forces
- Static and kinetic friction forces
- Air resistance
- Tension, or any applied force
- Normal force
- Propulsion force in a rocket

Work-energy theorem revisited

From earlier, work done by an **applied force** is:

$$W = \Delta KE + \Delta PE$$

Identify this applied force as an example of a non-conservative force, and state that, for any non-conservative force:

$$W_{nc} = \Delta KE + \Delta PE$$

This is the work-energy theorem in terms of non-conservative forces

The important point is that a non-conservative force does **not** conserve mechanical energy

A 0.6 kg ball is pitched from a height of 2 m above the ground at 7.2 m/s. The ball travels at 4.2 m/s when it is 3.1 m above the ground.

How much work is done by air resistance, a non-conservative force?

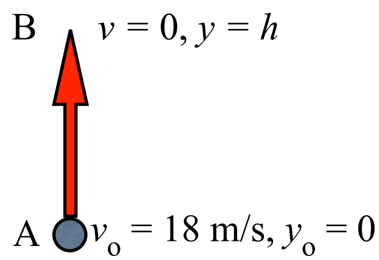
y_o = 2 m, v_o = 7.2 m/s
y_f = 3.1 m, v_f = 4.2 m/s

$$\begin{aligned} W_{nc} &= \Delta KE + \Delta PE \qquad \text{(work-energy theorem)} \\ &= \frac{m(v_f^2 - v_0^2)}{2} + mg(y_f - y_0) \\ &= \frac{0.6(4.2^2 - 7.2^2)}{2} + 0.6g(3.1 - 2) = -14.1 \text{ J} \end{aligned}$$

Air resistance does -14.1 J of work

6.78/70: A projectile of mass 0.75 kg is shot straight up with an initial speed of 18 m/s.

a) How high will it go if there is no air resistance?



No air resistance, so mechanical energy is conserved and $E_A = E_B$

$$\text{So, } mv_0^2/2 + 0 = 0 + mgh$$

$$\text{and, } h = \frac{v_0^2}{2g} = \frac{18^2}{2g} = 16.5 \text{ m}$$

b) If the projectile rises to only 11.8 m, find the average force due to air resistance.

$$\text{Work-energy theorem: } W_{nc} = \Delta KE + \Delta PE$$

$$\Delta KE = 0 - mv_0^2/2 = -(0.75 \text{ kg}) \times (18 \text{ m/s})^2/2 = \underline{-121.5 \text{ J}}$$

(final - initial)

$$\Delta PE = mgh - mgy_0 = (0.75 \text{ kg}) \times 9.8 \times (11.8 - 0 \text{ m}) \underline{= 86.7 \text{ J}}$$

(final - initial)

$$\text{So that } \underline{W_{nc} = -121.5 + 86.7 = -34.8 \text{ J}}$$

$$W_{nc} = F \times h, \text{ where } F = \text{average force of air resistance}$$

$$\underline{\text{Therefore } F = W_{nc}/h = (-34.8 \text{ J})/(11.8 \text{ m}) = -2.95 \text{ N}}$$

6.27/23: A model airplane of mass 0.9 kg is flying on a guideline at speed v_1 = 22 m/s in a horizontal circle of radius r_1 = 16 m. The person pulls the guideline until the radius of the circle becomes r_2 = 14 m. The plane speeds up and the tension in the string becomes 4 times greater. What is the net work done on the plane?

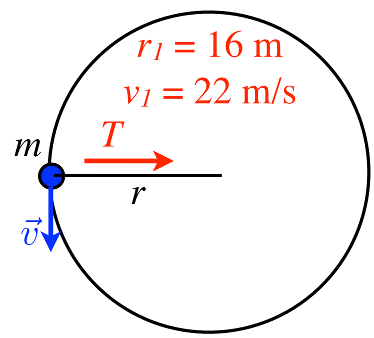
Work-energy theorem: $W_{nc} = \Delta KE + \Delta PE$, and PE = constant

So, $W_{nc} = \Delta KE = (v_2^2 - v_1^2)m/2$, what is v_2 ?

Motion in a circle: $T = \dfrac{mv^2}{r}$ $T_2 = 4T_1$

$$\frac{T_2}{T_1} = \frac{v_2^2}{r_2}\frac{r_1}{v_1^2} = \frac{v_2^2}{14}\frac{16}{22^2} = 4 \rightarrow v_2^2 = 1694\ (\mathrm{m/s})^2$$

$$W_{nc} = (1694 - 22^2) \times 0.9/2 = 545\ \mathrm{J}$$



From above

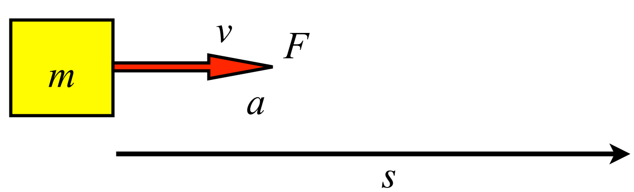
Power

Power is the rate of doing work, or the rate at which energy is generated or delivered.

Unit: 1 watt (W) = 1 J/s

$$\text{Power, } P = \frac{W}{t} = \frac{Fs}{t} = F \times \frac{s}{t} = Fv$$ (speed = distance/time)

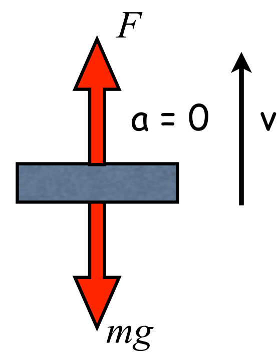
So P = Fv



Kilowatt-hour (kWh): the energy generated or work done when 1 kW of power is supplied for 1 hour.
1 kWh = (1000 J/s)×(3600 s) = 3,600,000 J = 3.6 MJ

A 300 kg piano is being lifted by a crane at a steady speed to a height of 10 m. The crane produces a steady power of 400 W.

How much time does it take to lift the piano?



Power $P = Fv$ (F = mg, force to lift piano at constant speed)

So $P = mgv$ and $\underline{v = P/(mg)}$

$$v = \frac{(400\text{ W})}{(300\text{ kg}) \times g} = 0.136\text{ m/s}$$

$$\text{Takes time } \frac{h}{v} = \frac{10\text{ m}}{0.136\text{ m/s}} = 73.5\text{ s}$$

6.67/59: The cheetah can accelerate from rest to 27 m/s (97 km/h) in 4 s. If its mass is 110 kg, determine the average power developed by the cheetah while it is accelerating.

Power = rate of doing work

Work done = ΔKE = $KE_{final} - KE_{initial}$

$= m(v_f^2 - v_i^2)/2$

$= 110\text{x}(27^2 - 0^2)/2 = 40{,}095$ J

This work is done in 4 s, so the average power developed is:

P = 40,095/4 = 10,000 W = 10 kW (13.4 hp)

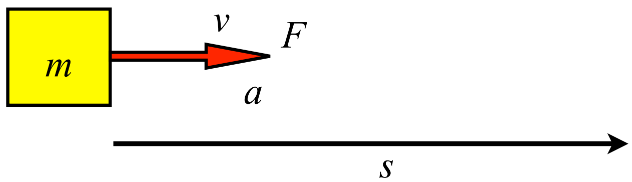
Power

Power is the rate of doing work, or the rate at which energy is generated or delivered.

Unit: 1 watt (W) = 1 J/s

$$\text{Power, } P = \frac{W}{t} = \frac{Fs}{t} = F \times \frac{s}{t} = Fv \qquad \text{(speed = distance/time)}$$

P = Fv



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