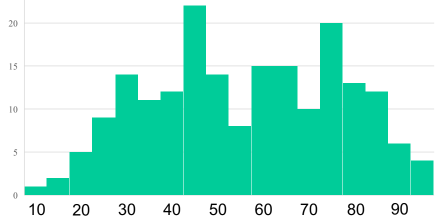
First Midterm Exam

- Combined statistics for both sections (**100** points):
  - average: 62.0
  - standard deviation: 20.7
  - 25% scored above 79.5
  - 50% scored above 62.0
  - 75% scored above 46.5

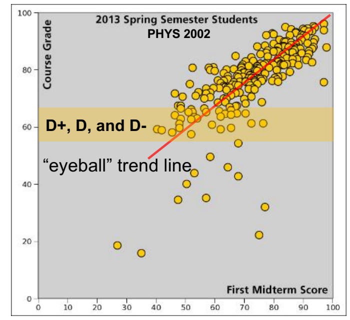


- **Please immediately check:**
  - Do the points on each page add up to the total at the top or bottom of the page?
  - Is that page-total transcribed correctly onto your front sheet?
  - Are the page-totals added correctly on your front sheet?
- In the histogram above, each bin is five points wide; bin "90," for example, counts the total number of people scoring 90 – 94.5, inclusive.
- Solutions for each form (A and B) are now posted in LON-CAPA.

First Midterm Score vs. Course Grade

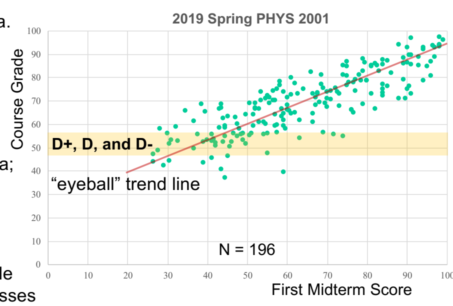
Please pick up your graded exam. They are grouped on the front desk by segments of the alphabet (A-C, D-K, L-R, and S-Z).

- Course grades tend to be higher than exam grades, because homework, class, and labs are often close to 100%.
- The first midterm predicts your course grade, usually within a letter grade, but deviations of two letter grades are seen.
- A few people who scored in the 50s on 2013's first midterm earned in the 80s for the course.
- Some people with respectable scores on the first midterm did miserably for the course — beware over-confidence.
- Nobody passed the course without taking all three exams **and** passing the lab.



First Midterm Score vs. Course Grade, cont.

- Compare to prior slide's data.
- The points plotted here exclude students with "FS" or "W" grades, but include students who kept trying, and still earned "F" grades.
- This slide is PHYS 2001 data; the prior one is PHYS 2002 data. Both courses were graded and structured quite similarly to this course; the key patterns closely resemble each other: the tend line passes well above the origin, and about 80% of students were within a letter grade of the trend line.



- Letter grade boundaries are set separately each time, depending in part on our judgment about the actual (as opposed to intended) difficulty of those exams that semester.

PHYS 2001 – Guest Instructor: Dick Piccard

- Thursday, 2/20: (OS 7)
  - Work
  - Energy
- Today, 2/25: (OS 7)
  - Return and Review Exam 1
  - Conservation of Energy
  - Power
- Thursday, 2/27: (OS 8)
  - Impulse
  - Momentum
  - Conservation of Momentum

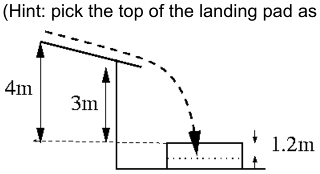
Un-stifle your cell phone after class. Be ready for Top Hat participation.

Homework Due Dates Changed: Assignment 6 and the first seven problems of Assignment 7 all remain due this Friday. The last four problems of Assignment 7 are now postponed a week, to Friday, March 6.

Do first what is due first!

Please pick up your graded exam. They are piled on the front desk by segments of the alphabet (A-C, D-K, L-R, and S-Z).

An 80-kg stunt-person starts at rest, slides down a roof, flies through the air, and lands on a large pad, which compresses 1.2 m in order to bring the stunt-person to a stop. Assume it is an icy day and the roof is frictionless. Ignore air resistance. What is the average force on the stunt-person due to the pad?
(Hint: pick the top of the landing pad as the h = 0 reference level.)



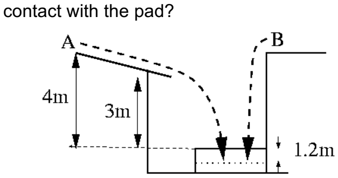
(A) 0 N (B) 940 N
(C) 2350 N (D) 3140 N
(E) 3400 N (F) 4080 N

$(KE_f + PE_f) = (KE_i + PE_i) + W_{NC}$

1. $(KE_F + PE_F) = (KE_0 + PE_0) + W_{NC}$
2. (0 + (–1.2)mg) = (0 + 4mg) + F*d*cos(180º)
3. (-1.2 m)mg = (4 m)mg + F*(1.2 m)*(-1)
4. 1.2F = 5.2mg
5. F = 3397 N ≈ 3400 N

	KE	PE	E_{TOT}
Top	0	mg(4 m)	(4 m)mg
Top of Pad	½mv²	0	½mv²
Rest	0	mg(-1.2 m)	(-1.2 m)mg

At the same time that Stuntman A slides down the roof (starting from rest), Stuntman B steps off a roof (starting at the same height and with initial vertical speed zero) on the other side of the street. Assume a "no-friction" roof and negligible air resistance. Which Stuntman is traveling faster when they make contact with the pad?

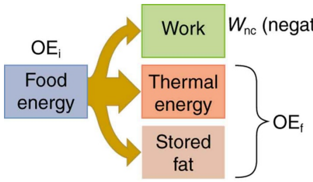


A. A faster
B. B faster
C. both have the same speed

- Start at same height and initial speed,
- End at same height,
- No friction; so . . .
- Lose the same potential energy, gain the same kinetic energy.

Work, Energy, and Power in Humans

(can also think of it as chemical energy, but it is not fully recoverable, so does not fit the physics usage of "potential energy")



W_{nc} (negative) (work done **by** person is opposite sign to work done **on** person)

(fat, starch, and protein all store energy; they differ in recovery efficiency and in time delay)

$OE_i + W_{nc} = OE_f$

Efficiency (eff) = (Useful Energy or Work Output) / (total Energy Input)

What is the minimum energy needed for you to climb a 20-m-tall cliff? Assume a mass of 70 kg (you plus clothing and equipment). Also assume that you are at rest before and after the climb.

(A) 14.3 J (B) 140 J (C) 196 J
(D) 463 J (E) 686 J (F) 13700 J

$KE_i + PE_i + W_{NC} = KE_f + PE_f$

Pick reference altitude at base of cliff

$0\text{ J} + 0\text{ J} + W_{NC} = 0\text{ J} + mgh$

$W_{NC} = (70\text{ kg})(9.8\text{ m/s}^2)(20\text{ m}) = 13700\text{ J}$

What is the minimum power required if this climb is accomplished over a time of 3 minutes? Recall that 1 Watt = 1 Joule/second.

(A) 76.2 W (B) 2380 W (C) 4570 W
(D) 8290 W (E) 12850 W (F) 41200 W

Power = (Energy or Work) / time

= (13700 J) / (180 s)

= 76.2 W

Even if you were a 100%-efficient machine, this would require almost doubling your energy consumption (just sitting there takes ~100 W).

If your body is only 0.20 (20%) efficient at creating useful energy from your energy input (food), what would be the energy input needed for the climb?

(A) 2740 J (B) 10960 J (C) 13700 J (D) 17100 J (E) 68500 J

Efficiency = Useful Energy / Energy Input

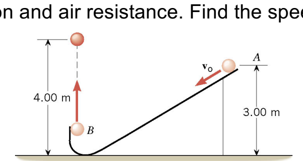
Energy Input = Useful Energy / efficiency
= (13700 J) / (0.20)
= 68500 J

How much 'non-useful' energy would be produced?
(typically in the form of thermal energy — "waste heat")

Energy input = Energy useful + Energy not useful

$E_{NOT\ USEFUL} = 68500\text{ J} – 13700\text{ J} = 54800\text{ J}$

A particle, starting from point A, is projected down the curved runway ($v_0 > 0$). Upon leaving the runway at point B, the particle is traveling straight upward and reaches a height of 4.00 m above the floor before falling back down. Ignore friction and air resistance. Find the speed of the particle at point A.



Initial: Leave point A
Final: Max Height
Ref Level: Table Top

A: $(KE_F + PE_F) = (KE_0 + PE_0) + W_{NC}$

No non-conservative forces

$(0 + mg(4.0\text{ m})) = (½mv_0^2 + mg(3.0\text{ m})) + 0$

Can cancel mass and solve

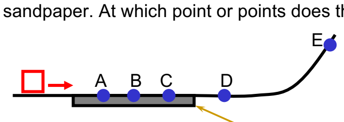
$(9.8\text{ m/s}^2)(4.0\text{ m} – 3.0\text{ m}) = ½v_0^2$

$v_0 = 4.4\text{ m/s}$

B: The speed going up when it passes though the altitude of point A will be equal to the speed it had when it left point A. And that speed matches the speed it will have when it has fallen back that far from the top. So calculate the final speed after a 1-meter free-fall from rest:

$$v_f^2 = v_i^2 + 2a\Delta x$$
$$v_f^2 = 0 + 2*(9.8\text{ m/s}^2)(1\text{ m})$$
$$v_f = \sqrt{19.6\text{ m}^2/\text{s}^2} = 4.43\text{ m/s}$$

A crate is given a kick by a spring such that it has 50 J of kinetic energy. It travels along a straight frictionless track until it hits a 10 m stretch of sandpaper. For this stretch, the frictional force is 4 N. The track becomes frictionless again after the sandpaper. At which point or points does the box have a velocity of zero?



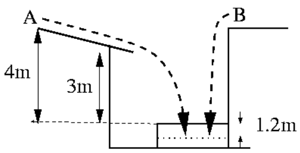
B is the center point of the sandpaper;
A and C are the quarter points.

A. A (1/4)
B. B (1/2)
C. C (3/4)
D. D (Flat after friction)
E. E (Highest point on slope after friction)
F. E and C
G. E and B
H. E and A

Can lose KE due to Work done by frictional force or by transforming to PE.

Total work done by friction = F*d*cos(180º) = 4 N*10 m*(-1) = -40 J, leaving the crate with 10 J. It then climbs up slope, gaining PE, stops momentarily at E, and comes back.
W = F*d*cos(180º), so losing 10 J requires -10 J = 4 N*d*(-1), so d = 2.5 m; stops at C.

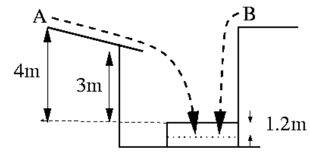
At the same time that Stuntman A slides down the roof without friction, Stuntman B steps off a roof (starting at the same height and with initial vertical speed zero) on the other side of the street. Which Stuntman makes contact with the pad first?



A. A first
B. B first
C. both make contact at the same time

- Conservation of energy doesn't help us here, because it hides the time information.
- A is not in free fall until leaving the roof, so for a while A's acceleration is smaller than B's acceleration; and A's path is longer, too.

At the same time that Stuntman A slides down the roof without friction, Stuntman B steps off a roof (starting at the same height and with initial vertical speed zero) on the other side of the street. The roof on which A is sliding is **not** frictionless. Which Stuntman is traveling faster when they make contact with the pad?



A. A faster
B. B faster
C. both have the same speed

Same loss of Potential Energy

Work due to friction reduces total energy of A.

So less impact Kinetic Energy for A

Bonus Slides

- The following slides were not shown in class. They are included to assist your studying.

Conservation of Energy in General

- So far, just mechanical energy (kinetic, gravitational, elastic, . . .)
- Other Energy (OE) types:
  - Thermal, Electrical, Chemical, Nuclear, Sound, Light, . . .
- "Energy can neither be created nor destroyed, but only converted from one form to another."

$$KE_i + PE_i + W_{NC} + OE_i = KE_f + PE_f + OE_f$$

- Non-conservative forces, such as friction, generally transform some of the energy into waste heat — more about that toward the end of the course.