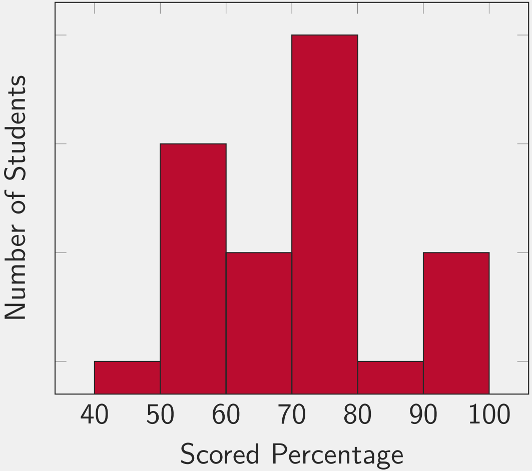
Announcements

- Video Homework due tonight
- New WebWorK due on Wednesday
- Test 2 Handbacks!
  - Don't panic, there will be options to get back some points
  - We'll discuss it more in just a moment
- New grade reports have been posted
- Polling: `rembold-class.ddns.net`

Test Discussion



- High: 97%
- Mean: 71%
- Std: 15.8%
- Median: 70%

Doing Test Corrections

You can earn back 50% of your missed points if you complete and turn in the following by next Monday at midnight. For each problem you missed that you want to get points back on, I need to see:

- A written description of what learning objective(s) the problem was testing and a statement of where you went wrong or where you got confused, as well as steps you can take to make sure you don't stumble again on this type of problem in the future.
- A newly written problem of your own devising which tests the same concept.
- Your worked (and correct!) solution of your written problem.

Please keep things organized and turn them in along with your test by next Monday.

Indiana Jones is inspecting what appears to be the resting point to the start of an old boulder trap. The boulder has long since rolled away, but Indiana can make out an old indentation where the boulder had compressed the rock beneath it and the rock never recovered. The indentation is circular with a radius of about 10 cm and a depth of about 1 mm. The pedestal that the rock used it sit on is 1 m wide by 1 m deep by 50 cm tall. Being an archaeologist, Indy naturally knows that softer rocks such as this have a Young's modulus of around 10 GPa. What was the mass of the boulder when it sat atop the pedestal?

Problem 2

90%

Indy launches a firework to try to scare away some sinister looking monkeys that are hanging around the edge of an old temple. The firework explodes (with a loud bang) into three pieces a short time later. Immediately after the explosion, the $10\,\mathrm{g}$ piece has a velocity of $\langle 0, 1, 2\rangle\,\mathrm{m/s}$, while the $25\,\mathrm{g}$ piece has a velocity of $\langle 10, 3, 2\rangle\,\mathrm{m/s}$. The final $15\,\mathrm{g}$ piece has a velocity of $\langle 0, -4, 0\rangle\,\mathrm{m/s}$. Assuming that no mass was lost during the explosion, what was the velocity of the entire firework the instant *before* it exploded?

Problem 3

54%

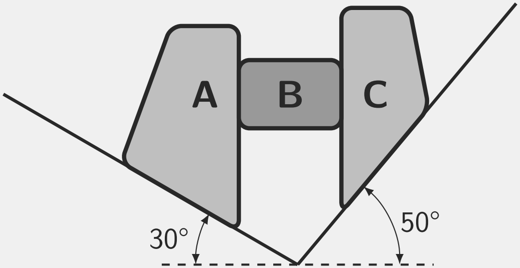
In a strange genre-crossover, Indiana enters an ancient portal which deposits him on an alien planet. Through careful observations, Indy is able to establish several facts:

- His planet is the only planet in this solar system. It is just his planet and its sun.
- It seems to take his planet about 80 standard Earth days to complete a single circular orbit around its sun.
- His planet is approximately 100 million (100×10^6) km from its sun.

Approximately how massive is Indy's new sun? Just for reference, Earth's Sun has a mass of about 2×10^{30} kg.

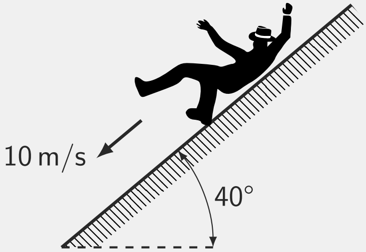
Problem 4

Back safely on the surface of the Earth, Indy is faced with yet another predicament. A precarious arrangement of rocks is situated as seen in the image below, with the two wedge shaped blocks pinning a middle block between them. At the moment, everything seems fine. But the sinister monkeys are back and Indy is worried one might stand atop the center block and have just enough mass to cause it to start sliding downwards. All of the rocks are rough and experience friction with both one another and the ground. Draw a free body diagram for each rock depicting the forces acting upon that rock and their direction. Angles should be labeled where appropriate, and the various forces clearly named. Once you've drawn the FBD for all three rocks, also clearly indicate what drawn forces are equal and opposite pairs. *You do not need to do anything beyond setting up all the free body diagrams and identifying the force pairs!*



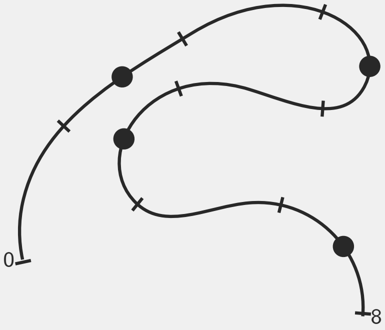
Problem 5

Still on Earth, Indiana Jones (75 kg) finds himself slipping and sliding down a long straight chute. The chute makes an angle of 40° with the horizontal and is rough in texture. Nearing the end of the chute, Indy is traveling at 10 m/s down the slope, and then 3 seconds later he has come to a stop. What is the coefficient of friction between Indy and the floor of the chute? Did you find the coefficient of static or of kinetic friction? Explain yourself.



Extra Credit

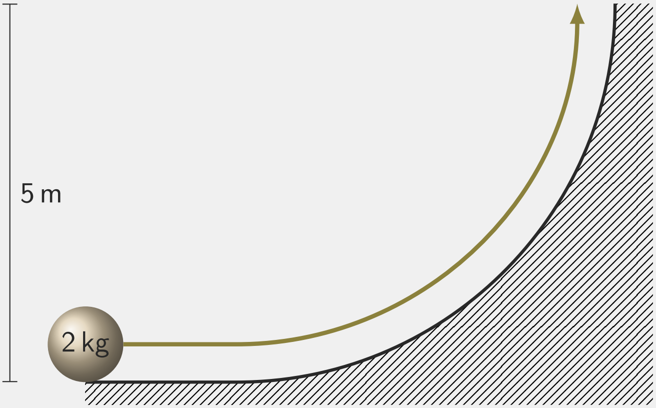
The graph below shows the speed of a particle as it travels along the path shown further below. Each of the vertical dashed lines on the plot corresponds to one of the ticks on the path. At the 4 points on the path indicated with large dots, sketch in the direction of $\frac{\mathrm{d}\vec{\mathbf{p}}}{\mathrm{d}t}$ at that point as best as you can.



Review Question

Suppose you move a ball up the quarter-pipe to the below right, which has a radius of curvature of 5 m and is frictionless. What is the work done by the gravitational force?

A. $-98\,\mathrm{J}$
B. $-49\,\mathrm{J}$
C. $98\,\mathrm{J}$
D. $19.6\,\mathrm{J}$

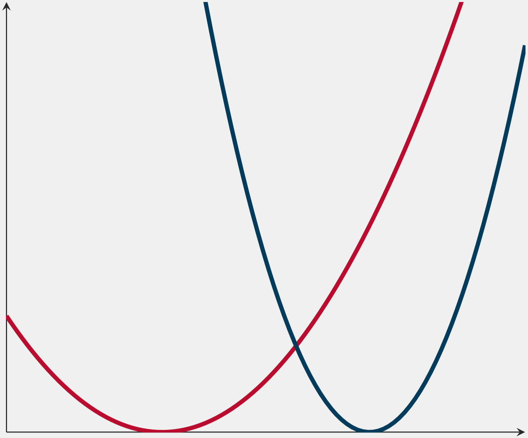


A Weird Rollercoaster

Suppose we have a rollercoaster in which we drop down an incline, cross a rough patch, and then are slowed to a stop by the electrostatic repulsion between a large charge and our charged cart. Suppose we start on a 30 m high hill. Our cart has a mass of 200 kg when loaded and a charge of 10 mC. The repulsion bumper has a charge of 50 mC and is located 100 m in the x-direction from the carts starting point. We'll be crossing a 10 m rough stretch with a coefficient of kinetic friction of 0.6. How far from the bumper will we come to a stop?

Effective Potentials

- Often times a system can have multiple potential energies
- We know we can just add them all up to get a total or net potential energy
    - The same works visually



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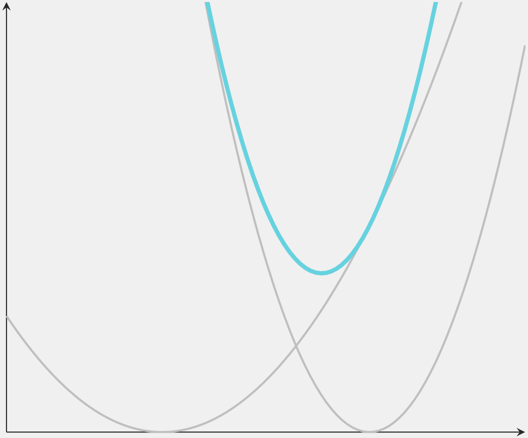
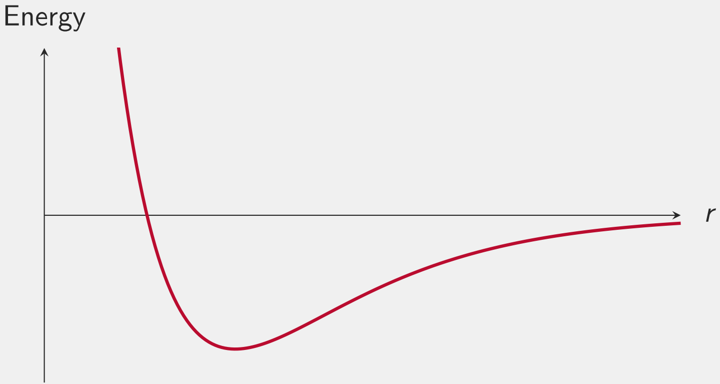


In the Darkness Bind Them

- When close to equilibrium we like to model atomic forces with springs
- Further away, we need to be a bit more careful (you can't ever escape springs!)



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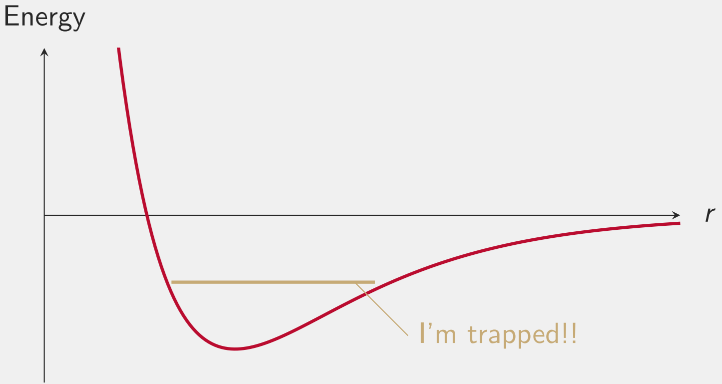

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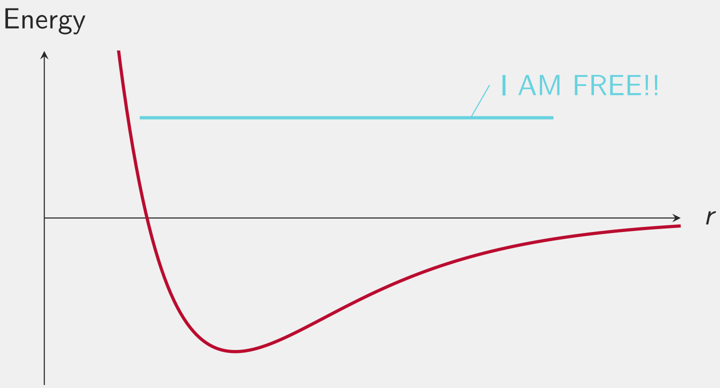
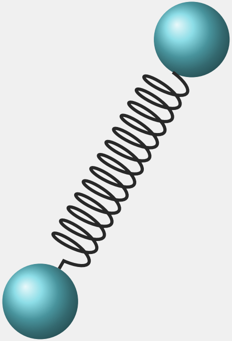


- For systems of masses
- Rest mass and kinetic energy of system related to center of mass
- But what of all the other types of motion/energy about that center of mass?
- Collectively termed internal energy
    - thermal
    - rotational
    - vibrational
    - chemical
    - etc
- Still talking types of potential energy



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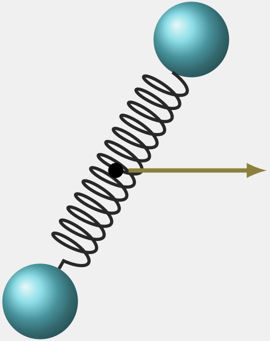

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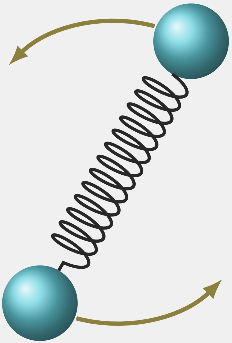

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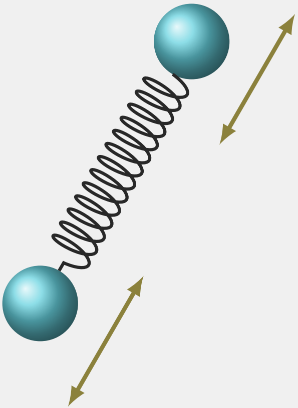

Thermal Energy

- Energy gets distributed randomly throughout the system by atomic springs
- These random bits of energy each atom possesses are what we refer to as thermal energy
- How to measure?
  - Could try to measure and find all the interatomic spring stretches and kinetic energies
  - Could measure one and then apply it to everything

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  - Turns out (shockingly, I know) that temperature is a good gauge of the thermal energy

Measuring Temperature

- Simple thermometers use a liquid that expands as it heats faster than the surrounding glass
  - More heat increases the chances that the spring stretch will be longer
  - Results in the material taking up slight more space, and thus expanding
- Temperature measured in SI units of degrees Kelvin
  - Kelvin has the same spacing as degrees Celsius, just a different 0 point
- The amount of energy to raise a object's temperature by 1 K is called its heat capacity.

This Heat Specifically

- How much does a change in temperature increase the thermal energy?
  - Depends on the material in question
  - A material's specific heat determines how much energy corresponds to a change in temperature of 1 K for a given amount of material.
  - For water, this is 4.2 J/(g K)
  - For gold it is 0.129 J/(g K)
- Can be described quantitatively by:

$$\Delta E_{thermal} = mC\Delta T$$

where

  - m is the mass
  - C is the specific heat of the material in question
  - ΔT is the temperature change in units of kelvin or celsius

Getting Souper Hungry

Getting home late from school one day, you'd like to heat up some soup to enjoy for dinner. The soup has been chilling in your refridgerator all day at 2 °C and you'd like it to be at a more pleasant 80 °C before consumption. Assuming you have about 1 L of soup ($1\,\mathrm{L}{=}0.001\,\mathrm{m}^3$) and soup is mostly made of water (same density and specific heat), how much energy do you need to add to prepare your dinner?

An Iron Enriched Diet

Say you didn't have a microwave or something to just add energy to your soup. Instead, you decide to drop a superheated cube of iron into the cold $2\,°\mathrm{C}$ soup. The iron has a mass of $500\,\mathrm{g}$, a specific heat of $0.42\,\mathrm{J/(K\,g)}$, and is initially at $150\,°\mathrm{C}$. You allow the two to come to an equilibrium temperature (in an insulated environment) and then pull it out to enjoy. How hot is your soup?

Ballistic Heating

Say you fire a 5 g bullet into a large tank of insulated water. The bullet is initially traveling at 500 m/s and comes to a stop after entering the tank of water. If there is 10 L of water in the tank that was initially at 20 °C, approximately how hot is the water in the tank now?