Tuesday April 23

Topics for this Lecture:

• *Review for final*

• Assignment 14 due Friday

The comprehensive final is Monday April 29th 2:30-4:30pm in Walter Hall (room depends on your last name).

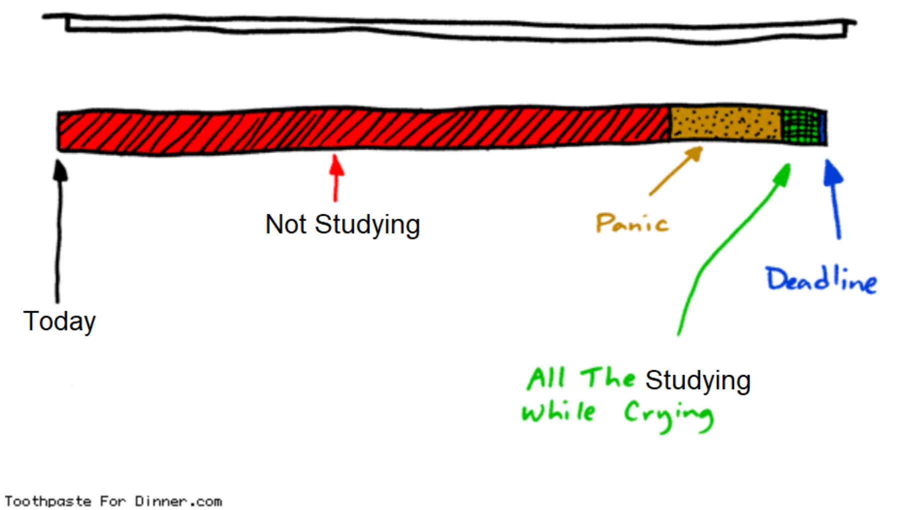
- A-H -> Walter 145
- I-Z -> Walter 135

If you have an exam-schedule conflict, immediately email Meisel@ohio.edu to let me know which of your other exams conflicts with this one. It is possible the other class will have to accommodate your situation.

Study Tips:

- Look at old TopHat questions
- Try a problem before looking at the solution
- Focus on solution **processes**, not equations

What not to do:



Class Review: Whirlwind tour of PHYS 2001

- Topics: (Section 1, Section 2, Section 3. Final is ~1/2 Section 3, ~1/2 Sections 1&2.) — 📖 In OpenStax
  - Kinematics (Ex.: soccer ball trajectory, free-fall, braking time) — 📖 Ch. 2-3
  - Forces (Ex.: tension of rope holding weight, free-body diagram) — 📖 Ch. 4-5
  - Torque (Ex.: person on a bridge, weight hanging from a beam) — 📖 Ch. 9
  - Energy & Work (Ex.: speed of dropped thing just above ground) — 📖 Ch. 7
  - Momentum conservation (Ex.: collisions, bullet & block) — 📖 Ch. 8
  - Circular Motion (Ex.: linear speed of rotating object, ice skater) — 📖 Ch. 6
  - Simple Harmonic Motion (Ex.: mass & spring, pendulum) — 📖 Ch. 16
  - Fluids (Ex.: buoyancy, water speed in an expanding pipe) — 📖 Ch. 11,12
  - Thermal Physics (Ex.: expansion of rod, equilibrium temp.) — 📖 Ch. 13,14
  - Thermodynamics (Ex.: engine efficiency, cycles) — 📖 Ch. 15

*Anything covered in the lecture notes is fair game.
*TopHat questions, practice exams, homework problems, & pre-class assignments all contain the types of questions that could be on the exam.

Study Tips

***Recommended study procedure*:**

1. Review notes
2. Try typical practice problems (a couple per topic, e.g. TopHat Q's)
3. Look at lecture notes for the questions you struggled on & possibly consult the relevant section of the book
4. Go back to step 1 until you feel at least ok about most topics
5. Try the practice exam in a realistic setting.
6. Zero-in on the topics you're still struggling on, trying practice problems, reviewing the notes & repeating.

stressed out!

General comments:

- At least 8 hours of studying is probably necessary to do well. Likely more.
- Making an equation sheet doesn't really count as studying. Just like copy-pasting isn't the same as reading & comprehending.
- Try practice problems without looking at the solutions. The solution will almost always look clear/obvious when reading it, but that won't mean you can actually reproduce it!
- <u>Focus on the relevant process for solving a class of problems.</u>

Exam Taking Tips

- Stay calm.
- Work on the problems that are easy for you first.
- Work your way through progressively tougher ones.
- If you get stuck on a problem, move to a different one and revisit it later.
- Read over your exam carefully once you're finished to make sure you didn't miss anything, read a problem wrong, or make a small mistake.
- Write something down for every question.
  You'll get partial credit, e.g. for the correct equation.

NOTE:

The following are general tips for major items related to a given topic, but they are by no means are comprehensive.

Anything presented in class this semester is fair game.

The following information will be on the cover of your exam sheet:

Numerical Constants and Conversions:

femto 10^{-15}; pico 10^{-12}; nano 10^{-9}; micro(μ) 10^{-6}; milli 10^{-3}; centi 10^{-2}; kilo 10^{3}; Mega 10^{6}; Giga 10^{9};

$g = 9.80\ m/s^2$; $G = 6.673\times10^{-11} N\cdot m^2/kg^2$

1 mi = 1.609 km; 1 in = 2.54 cm; 1m = 39.4 in; 12 in = 1 ft; 1 m = 3.28 ft;

1 mi = 5280 ft; 3.16 × 107 s = 1 year; 1 rev = 360° = 2π rad.

$I_{point}=MR^2$; $I_{hoop}=MR^2$; $I_{sphere}=\frac{2}{5}MR^2$; $I_{solidcyl}(disk)=\frac{1}{2}MR^2$

$\rho_{water} = 1000.\ kg/m3$; $\rho_{air} = 1.29\ kg/m^3$; 1 atm = $1.013\times10^5 Pa$;

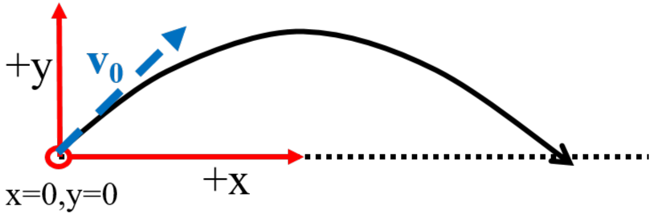
T(K) = T(C) + 273.15

Water: Specific Heat = 4186 J/kg °C ; $L_{vaporization} = 2.26\times10^6$ J/kg ; $L_{fusion} = 3.33\times10^5$ J/kg

Specific Heat(Ice) = 2090 J/kg °C; Specific Heat(Steam) = 2010 J/kg °C

$A_{SQUARE} = l^2$; $A_{CIRCLE} = \pi r^2$; $V_{CYL} = \pi r^2 h$

Kinematics



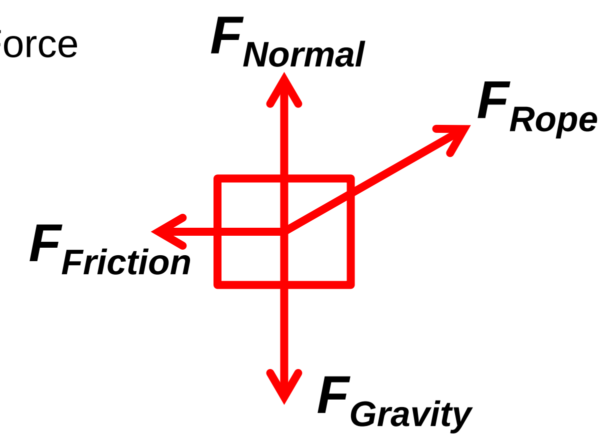
- How to recognize:
  - Trajectories, motion with linear acceleration
- Tips for solving:
  1. Draw (if not drawn already)
  2. What information do you know?
  3. What do you want to know?
  4. Which of your equations will get you (2) from (1)?
  5. Work through algebra of that equation.
  6. If it doesn't work-out, go back to (4) and try another equation.
- Notes:
  - Horizontal & vertical motion in a 2D-kinematics problem can both be solved like separate 1D-kinematics problems. They are only linked in time.
  - Be sure to cancel-out irrelevant variables in your equations when you can. For example, if the initial velocity is zero.

<u>2D Projectile motion eqns.</u>

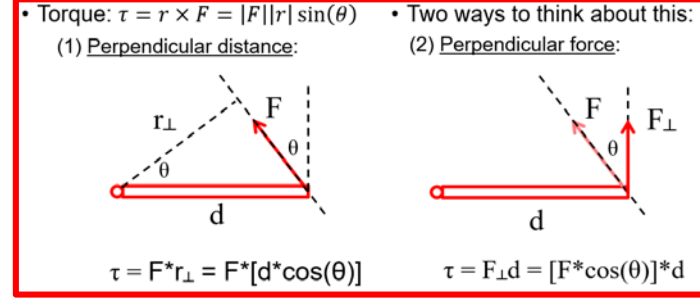
1. $v_x = v_{x,0}$
2. $x = x_0 + v_{x,0}t$
3. $v_y = v_{y,0} + a_y t$
4. $y = y_0 + v_{y,0}t + \frac{1}{2}a_y t^2$
5. $y = y_0 + \frac{1}{2}(v_{y,0} + v_y)t$
6. $v_y^2 = v_{y,0}^2 + 2a_y(y - y_0)$

Forces & Equilibrium

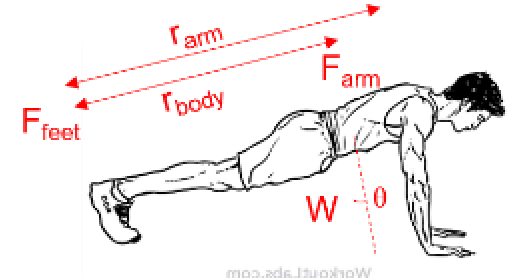
- How to recognize:
  - Free-body diagram, pushing and/or pulling happening (not about an axis), acceleration due to pushing/pulling is being asked for.
- Tips for solving:
  1. Draw a free-body diagram (i.e. labeled arrows for each force)
  2. Apply newton's 1st law: $\Sigma F = ma$.
  3. Do the algebra to find the missing force or the acceleration.
- Notes:
  - If an object is not accelerating, the forces must be balanced.
  - Should know formulae for:
    - Gravity, Buoyancy, Friction, Normal Force, Centripetal Force



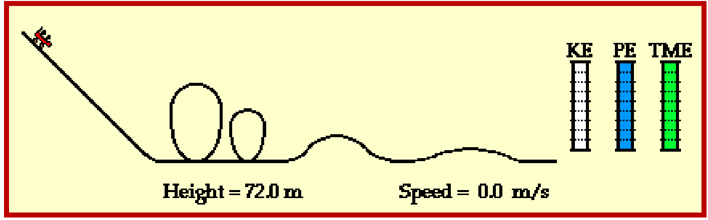
Torque & Static Equilibrium



- How to recognize:
  - A force or forces are acting on an object, but aren't applied directly to the center of an object.
- Tips for solving:
  1. If it's not rotating or accelerating, use static equilibrium: $\Sigma F_x=0$ & $\Sigma F_y=0$ & $\Sigma\tau=0$.
     If it is, then you're probably just being asked for torque.
     Or for the angular acceleration due to torque: $\tau=I\alpha$.
  2. Draw a free-body diagram.
  3. Pick an axis of rotation.
     If you want to ignore a force, put the axis of rotation where it is applied.
     If you want to find a force, put the axis of rotation in a place so that the other force(s) create a net torque.
  4. Do the algebra for the static equilibrium equations.
- Notes:
  - The weight of an object pulls down from its center of gravity.
    For a uniform object, this is its geometric center.

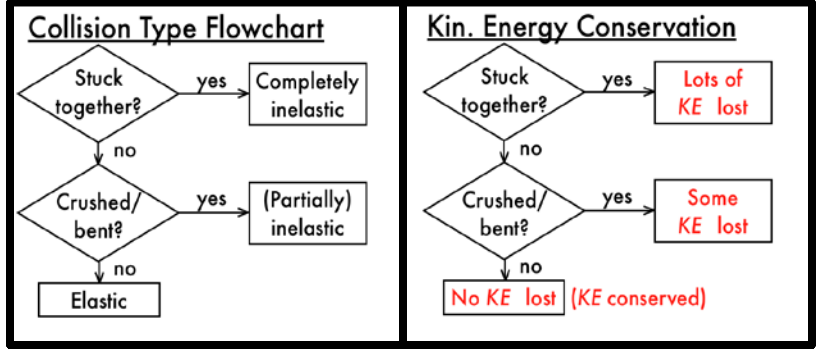


Energy & Work



- How to recognize:
  - You're given a height of an object at one location, but asked for the speed at another (or vice versa). You know a non-conservative force and are asked for an energy change (or vice versa).
- Tips for solving:
  1. Employ energy conservation, minus energy removed by non-conserving forces.
  2. $\Sigma PE_i + \Sigma KE_i = \Sigma PE_f + \Sigma KE_f + W_{NC}$
  3. If you know the non-conserving force, $W=Fd\cos(\theta)$
  4. Work through the algebra.
- Notes:
  - Potential energy is with respect to some reference height, which you choose.
  - Typical non-conserving forces are friction or the force of an object being indented as it is impacted (e.g. a landing pad for a stunt person).
  - If you're asked for information regarding a trajectory (e.g. max height, velocity before impact), but you don't need time information, this can be easier than using 1D kinematics.

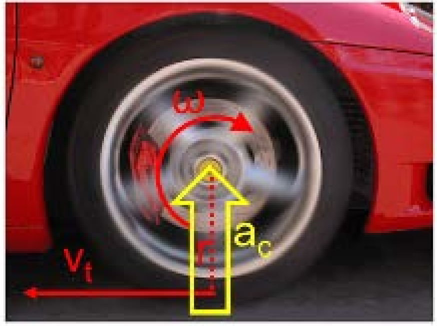
Momentum Conservation



Patrick M. Len

- How to recognize:
  - Objects are colliding.
- Tips for solving:
  1. Draw your initial & final situations. Label all object(s)' velocities.
  2. Employ momentum conservation.
  3. $\Sigma p_i = \Sigma p_f$
  4. Work through the algebra to find the missing information.
- Notes:
  - Impulse is equal to the change in momentum.
  - If no kinetic energy is lost, the collision is elastic.
  - If some kinetic energy is lost, the collision is inelastic.
  - If the objects stick together, a lot of kinetic energy is lost, and the collision is completely inelastic

Circular Motion

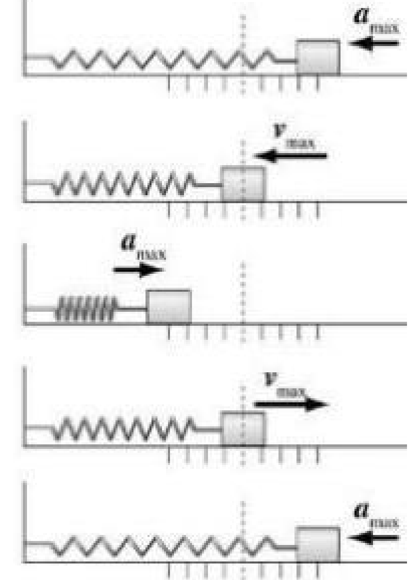


- How to recognize:
  - Something is moving, but not in a straight line.
- Tips for solving:
  1. Convert linear variables to angular variables when necessary. Or convert the other way when necessary.
  2. If something is spinning, but changing its mass distribution, employ angular momentum conservation: $I_i\omega_i = I_f\omega_f$
  3. If a torque is applied, use the analogy to Newton's 1st law: $\tau = I\alpha$
- Notes:
  - Newton's law still applies for centripetal force: $F_c = ma_c = mr\omega^2$

Equations for kinematics in 1D & Newton's Laws apply to rotational motion as well, by subsituting the appropriate quantities:

Linear Quantity			Corresponding Rotational Quantity		
Quantity	***Variable***	***SI units***	***Quantity***	***Variable***	***SI units***
length	x	m	angle	$\theta = s/r$	rad
velocity	$v = \Delta x/\Delta t$	m/s	angular velocity	$\omega = \Delta\theta/\Delta t$	rad/s
acceleration	$a = \Delta v/\Delta t$	m/s^2	angular acceleration	$\alpha = \Delta\omega/\Delta t$	rad/s^2
mass	m	kg	moment of inertia	I (formula depends on object shape)	$kg*m^2$
force	F = ma	N	torque	$\tau = I\alpha$	N*m
momentum	p = mv	kg*m/s	angular momentum	$L = I\omega$	$kg*m^2/s$

Simple Harmonic Motion



- How to recognize:
  - Something is repeating, e.g. in circles or moving back & forth.
- Tips for solving:
  1. What do you know?
  2. What do you want to know?
  3. Look at your list of relevant equations to figure out how to get to (1) from (2).
- Notes:
  - Newton's laws still apply, i.e. F=ma.
  - A cycle is anything that repeats: oscillations, circles, …
  - Position, velocity, and acceleration are related as they are in 1D kinematics.

Spring:

$$F_{applied} = kx \qquad \omega_{spring} = \sqrt{\frac{k_{spring}}{m_{weight}}} = \sqrt{\frac{k}{m}}$$

Note: T, f, ω are ***independent of amplitude!***

$$x = A\cos(\omega t) \qquad x_{max} = A$$

$$v = -A\omega\sin(\omega t) \qquad v_{max} = A\omega$$

$$a = -A\omega^2\cos(\omega t) \qquad a_{max} = A\omega^2$$

Note: $f = 1/T$

$\omega = 2\pi f$

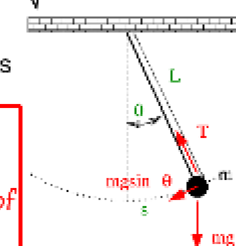
T, f, ω independent of oscillation amplitude.

Pendulum:

$$\omega_{pendulum} = \sqrt{\frac{g}{l_{pendulum}}} = \sqrt{\frac{g}{l}}$$

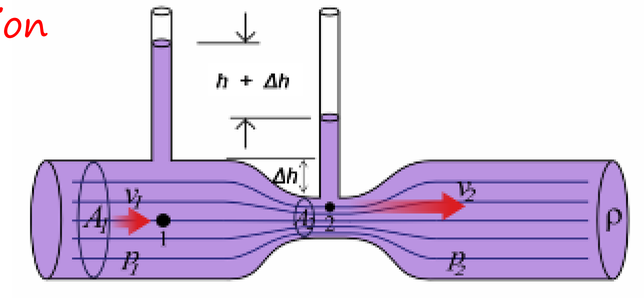
F ≈ -mg θ

F ≈ -(mg/L)s



Fluids

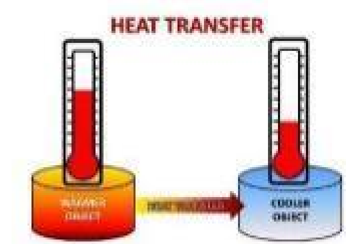
*The Hagen-Poiseuille equation will not be on the exam.

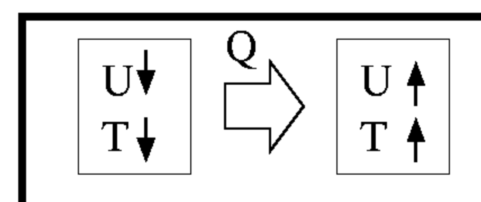


- How to recognize:
  - Something is floating or flowing.
- Tips for solving:
  1. If floating, draw a free-body diagram including the buoyancy force: $F_{buoyancy}=\rho_{fluid}V_{displaced}g$.
  2. Solve for the missing piece of information with algebra.
  3. If flowing, use Bernoulli's equation and the continuity equation to relate things you know at one point in the system to things you know at a later point.
  4. If looking for pressure with depth: $P=\rho gh$
- Notes:
  - Continuity says that if you squeeze a flowing fluid into a smaller diameter pipe, it will speed up.
  - Bernoulli says that if you slow-down a fluid, the pressure will increase.
  - Pressure in a fluid is height-dependent.
  - The pressure above atmospheric pressure is the gauge pressure. The pressure including the atmospheric pressure is the absolute pressure.

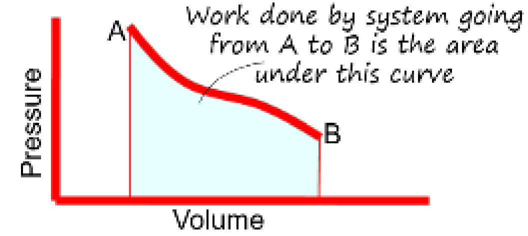
Thermal Physics

- How to recognize:
  - Some object is responding to being heated/cooled by some other object or heat source.
- Tips for solving:
  1. Convert temperature information into favorable units (if it isn't already). These will be the units that match whatever constants you're provided.
  2. If heat is being transferred, use the heat-transfer equation: $Q=mc\Delta T$.
  3. If a hot object is touching a cold object, note that the cold object will gain some heat and the hot object will lose some heat. $Q_{gained}=Q_{lost}$.
  4. If a phase transition is occurring, take into account the heat required: $Q=mL$.
  5. If an object is expanding, are you asked for a linear or volumetric quantity? Be sure to use the correct formula.
- Notes:
  - Stick to Kelvin (or Celcius), but make sure all the units are consistent.
  - An object with a higher heat capacity takes more heat-input raise its temperature





Thermodynamics



- How to recognize:
  - An ideal gas is undergoing some change or a heat engine/heat pump/refrigerator is being discussed.
- Tips for solving:
  1. For an ideal gas: PV=nRT.
  2. Work through the algebra to find-out how the variable you're asked for changes when all of the other variables change in the way described.
  3. For cycles of transitions: There is no net internal energy change: $\Delta U=0$.
  4. Apply the first law of thermodynamics if need be: $\Delta U = Q-W$.
  5. If a heat engine, or pump, or refrigerator, the amount of work put-in or generated depends on the difference between the heat transfer to/from the hot reservoir and the heat transfer to/from the cold reservoir: $Q_H-Q_C = W$.
  6. Efficiency/performance is how much stuff you get-out over how much stuff you get in: Engine: $e=W/Q_H$, Pump: $COP=Q_H/W$, Refrigerator: $COP =Q_C/W$.
- Notes:
  - The Carnot efficiency is the maximum theoretically possible efficiency.
  - The direction of the transition on the PV-diagram matters.

Next class will be all practice problems. Feel free to come with questions.

Thanks for a solid semester.

Best of luck on the exam.

Feel free to contact me in the future with any physics/astrophysics questions that may cross your mind.