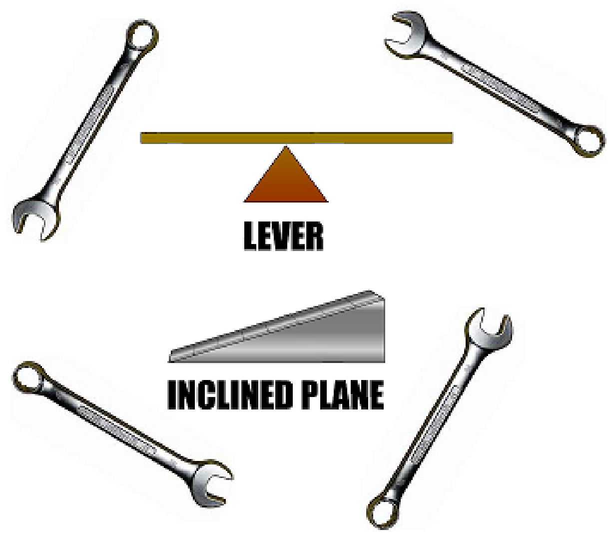
Physics Traditional 1314 Williams

Circular Motion, Torque & Simple Machines

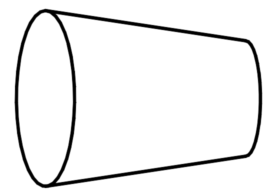
Packet 4/ Chapters 8



Some Circular Motion Questions

1. What are the two ways an acceleration can be produced?
2. Another name for "center seeking"?
3. Write the equation for a_c:
4. Equation practice: A car goes around a turn with a radius of 50 m at a speed of 20 m/s. What is a_c?
5. Describe the direction of the net force to maintain an object in circular motion
6. What is the equation to find a_c and F_c, the centripetal acceleration and the centripetal force?
7. What is the name for "some mysterious force" that *seems* to push you outward when you are in circular motion?
8. You are leaving HCHS driving on Grant street. You make a left turn on to 55th. While you are making this left turn you are in circular motion. You swear you feel some mysterious force pushing you to the right as you make this turn. Actually, your inertia wants you to go straight instead of left, so it you it seems like something is pushing you right. You need a real force to push you in the direction of the center of the circle you're turning in. What is the name of the real force you need to provide for you to stay in circular motion?
9. If a mass is a sphere, you can treat gravity computations as though all the mass were at a single point in the ___________ of mass of that sphere.
10. Your car moves around a level circular track at steady speed. Which is true?
    a. Your car tires must push with a force to the outside of the track in order to maintain this motion
    b. Your car tires must push with a force to the inside of the track in order to maintain this motion
    c. No force is required since a component of the normal force provides all the necessary force
    d. It depends on if the motion is clock-wise or counter clock-wise
11. A water bottle is attached to a string and swings around in a circle. Which of Newton's laws implies the water bottle to move in a straight line (constant velocity)?
    a. First
    b. Second
    c. Third
    d. Newton's law of circular motion
12. a_c (centripetal acceleration) is:
    a. proportional to the radius
    b. proportional to the radius squared
    c. inversely proportional to the radius squared
    d. none of the above
13. It's an icy day and you are trying to follow a left curve on a level highway. The COF between the road and your tires is so low (assume zero) that you begin to slide on the icy pavement. Your car may wind up in
    a. The ditch on your right
    b. The ditch on your left
    c. Sliding straight toward oncoming traffic
14. You're part of a highway construction team. You have an obstacle on the land and your road needs to make a relatively sharp left curve. How does this affect your road design?
    a. It does not affect it, you just build ordinary highway road to the left to avoid the obstacle
    b. You bank the road so it's tilted down from left to right
    c. You bank the road so it's tilted up from left to right
    d. You make the road extra tacky in the section, so car tires don't slip as easily while following the curve
15. The surface gravity on a planet depends on
    a. The distance that planet is from the sun and the mass of the sun
    b. The distance from the center of that planet to the surface and the mass of the sun
    c. The distance from the center of that planet to the surface and the mass of that planet
    d. The rate of spin on planet (length of day) and how far you are from the center of mass of the planet

16. During the spin cycle on a washing machine, water leaves through holes in the cylinder:
    a. Because centrifugal force flings the water straight out the holes in the cylinder
    b. Because holes can't push with the necessary centripetal force for the water's circular motion
    c. And continues its circular motion outside the cylinder
17. You are flinging a mass attached to a string over head. The mass moves in a circle. Which is false:
    a. The string pushes on the mass causing it to change the direction it moves in
    b. The mass cannot possibly be moving at constant speed and go in a circle
    c. Tension in the string provides the centripetal force necessary for the circular motion
    d. The mass must lean down slightly, so string tension can lift if up
18. You are the planet mars. You move in a circle around the sun. This process you do is called:
    a. Rotation
    b. Revolution
    c. Centripetal motion
    d. Centrifugal motion
    e. You are in a smooth-walled gravitron. Unfortunately, you made a tragic fashion decision this morning.
19. Imagine pushing forward on the front of the cup at right.
    a. Looking down, the cup will revolve counter-clockwise
    b. The cup will make a right turn
    c. The cup will make a left turn
    d. The cup will rotate clockwise



20. Earth is 80 times more massive than the moon. If the earth pulls on the moon with a force of -1.919E+20 N, then the moon pulls on the earth with:
    a. A force whose magnitude is much less owing to the moon's much smaller mass
    b. A force whose magnitude is much greater owing to the moon's orbital velocity
    c. A force whose magnitude is exactly the same, in accordance with Newton's 3rd law
    d. A force whose magnitude is exactly the same, in accordance with Newton's 1st law
21. What is the name for the word that means "center seeking"?
22. Is centripetal force a "real force"
23. There are two ways acceleration can be produced. Name both of them:
24. What is the name for the ("mysterious") illusionary force that means "center fleeing"?
25. Which would you say: the earth "rotates" or "revolves" every 24 hours and why?
26. A car makes a turn at 4.5 m/s (10 mph). What turning radius would produce an acceleration of 5 m/s^2?
27. What's special about a "geosynchronous orbit"?
28. A road is has cars traveling at 40 mph (18 m/s) according to the local speed limit. At one point, a sharp turn is necessary and the turning radius is 100 m. The road is level (not banked). What acceleration is felt by the car and the driver?
29. Begins with the letter 'f': What provides the necessary centripetal force?
30. You're ice skating, moving in a circle. The force pushing you to the center of that circle is:
    a. The force of your skate pushing on the ice
    b. The force of the ice pushing on your skate
    c. The centripetal acceleration from your circular motion
    d. The centrifugal acceleration from your circular motion

Torque Practice Problems

1. A sports car typically puts out about 300 foot-pounds of Torque. How much torque is this in N-m? (407 N-m)

2. A bike rider has a mass of 60 kg and places half her weight straight down on the right pedal. The pedal is attached to the bike gear housing by a lever arm having a length of 0.10 m. How much torque in N-n did the biker apply?(29.4 N-m)

3. A logger attaches a steel cable to the top of a 45 m tall tree and is able to just pull down the tree using a tension force of 1200 N. If the angle between the cable and the tree is 30 degrees, how much torque was provided via the cable guy? (27000 Nm)

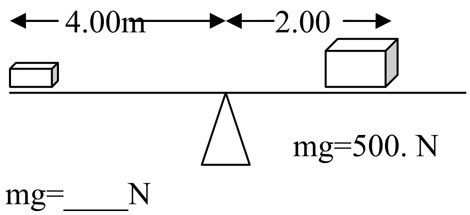
4. Where should a 100 N girl sit on a teeter-totter to balance her dad who is 200N and he sits 1 meter from the fulcrum. Teeter-totter has a weight of 50 N and has a fulcrum exactly at the middle of the teeter-totter. (2m)

5. A 600 N window washer is standing 1m from the left edge of a 4m long, 200 N scaffold. There are 2 cables on each end of the scaffold. How much tension is in each cable? (hint: imagine it tips on one edge so that one cable provided no torque)
(T1=550 N, T2=250N)

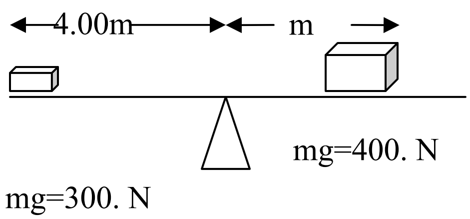
Torque Problems

Find the missing forces and distances using torque. Show formulas!

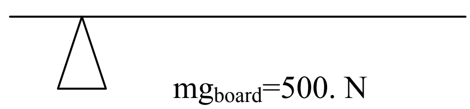
1.



2.

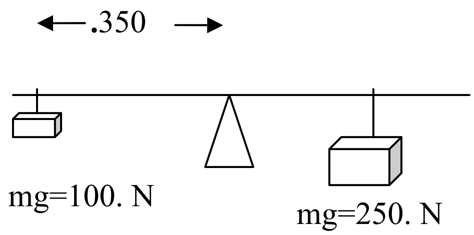


3. You are TIRED of babysitting your younger brother and would much rather spend the time chatting with your buddies on your cell phone. So, you take him to the park. Unfortunately, he wants to teeter totter, which usually requires two people. Inspiration strikes. Calculate where you could put your little brother (mass = 30.0kg) so he could teeter totter by himself. Presume the weight of the board is 500.N. The entire board is 8.0m long.

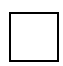


Hint: the center of mass is the spot where the entire mass of an object appears to be located. This is where all of the weight of the board seems to act and is the spot where it would balance on your finger!

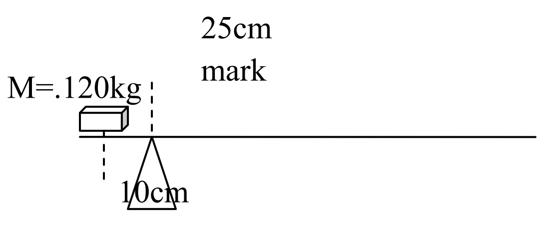
4. Two objects are hung from a bar whose own mass is so tiny we can ignore it. If the 100. N object is hung .350 m from the pivot, where must the 250. N object be hung so the bar will balance?



5. For the above problem, what is the normal force on the bar due to the pivot pushing upward to hold it up? Hint: do a force diagram on the bar.



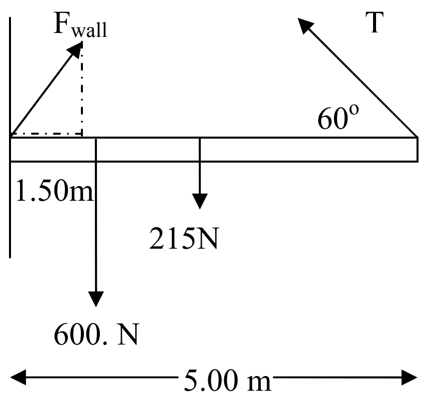
6. If a .120 kg mass hung at the 10.0 cm mark on a meter stick makes the meter stick balance perfectly if the pivot is at the 25.0 cm mark, what are the mass and weight of the meter stick?



7. A 10.0m beam weighing 500.N has a 200. N weight 3.00 m from the left end. What is the tension in each supporting rope? Hint: begin by putting the pivot at the right end!

Torque Challenge Problem: the Sign

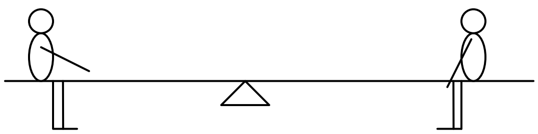
A 5.00 m board weighing 215 N is attached to a wall by a hinge that allows the board to rotate vertically. Its far end is supported by a wire that makes an angle of 60. degrees with the horizontal. A 600. N person is standing 1.50 m from the wall.
a) find the tension (T) in the wire.



b) Find the x and y components of the force exerted by the wall. Hint: use torques AND sum of forces….

Torque and Circles practice problems

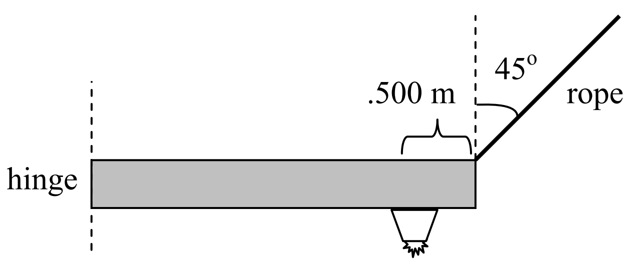
1. You are sitting 2.5m from the pivot of a teeter totter. Your friend Uriah is sitting on the other side of the teeter totter, 3.0m from the pivot. If your mass is 70. kg and Uriah mass is 60. kg, where should your 35kg little brother Tongo sit so you will all balance?



Answer = .14m on your side

2. A 200 N sign which is 3.50 meters long is held up by a 45° rope on the right and a hinge on the left. A 25.0 N spotlight is attached to the sign .500 m from the right end.

a) What is the tension in the rope? Hint: put your pivot at the left side, and then



b) What is the force at the hinge? What is the angle of that force?

Answers: T = 172 N; Hinge = 160 N

3. A 3.00kg mass is swung from a rope is a HORIZONTAL circle of radius .800 m at a speed of 4.00 m/s. What is the tension in the rope? Hint: The mass moves in a horizontal circle, but the tension is *not* horizontal! Draw a force diagram and you'll see Ft is at an angle!

Answer: Ft = 66.8 N at 26.1^{o} (Ftx = 60.0 N; Fty = 29.4 N)

4. The same mass is swung in a VERTICAL circle at the same speed as before. Find the tension:
a) when it is a the top of the circle

Answer: Ft = 30.6 N

b) When it is at the bottom of the circle

Answer: Ft = 89.4 N

c) When it is midway between the top and bottom of the circle (on the side). Remember—it is still a vertical circle!

Answer: 60.0 N

Physics Olympics Project

Goal:
Students create competitions and take turns hosting for a day. First, second and third place medals are awarded each day of competition for each competing team and each team awards a first, second and third place medal based on individual performance. The hosting team will also assign first, second and third place individual medals. Ties are not allowed.

At the end of the competition, teams may be asked to evaluate which hosting teams did the best job taking into account all factors including whether earlier hosting teams were at a disadvantage by "having to go first".

Teams:
There will be exactly four teams assigned team numbers by choice (who wants to go on which day), or by lot (teacher picks at random). You may choose your own team members, but there should be no teams larger by more than one person than any other teams. The teacher reserves the right to modify teams for any reason at any time, but will generally only do so to resolve a size inequity.

Themes:
Spirit and adherence to Olympic traditions will have some small value. Please take that into account when thinking of team names and competition names and where appropriate any equipment decorations, etc.

Points:
Points are earned on competitive performance as a team based on event skills, competitive testing and based upon teacher evaluation of effort/performance. Individual and team medals will play a role as well, so it's important to do well for your team as both a host and a competitor. There will be a possible 40 lab points for this project; 10 pts for hosting and 10 pts per competing-day. Additional grade curving is possible depending on the quality of work seen.

Hosting:
Host teams are responsible for the events of their day running smoothly, fairly and for providing a physics-related event that will help give participants practice and apply knowledge and skills learned thus far this year. Host teams may report to the teacher a particular team and a particular individual exhibiting particularly good sportsmanship. Conversely, they may also report participants with poor sportsmanship (uncooperative, cheating, complaining, not trying, rude behavior, etc.). The team voted best host team at the end of the Olympics will get 10/10 and other teams will get fewer points based on how they did and the overall hosting quality. A good host team will communicate how to prepare for tomorrow's event by writing on the board or possibly announcing and giving out some kind of homework (to prepare skills for next day), possibly with a key.

Lab event(s)
This is the fun part of the event. Events require BOTH a physical skill and direct physics knowledge. As host, you need to create an event or events for physics athletes to do. It should also come with some questions/calculations for competitors to solve. You can choose if it must be answered individually, in pairs or as a whole team. Teams must decide who to compete based on skill sets of physical ability as well as knowledge, etc. The events are up to you, but must be safe and neat and the room must be neat and clean by the time the bell rings. Some topic ideas that come to mind:

1. Shuffleboard friction. Push a puck of some kind a distance and compute COF, KE, work, F_f, etc.
2. Egg drop: Provide materials and drop an egg from a given height and see if it survives the fall. Compute, GPE, KE, discuss impulse-momentum theory, etc.

3. Impulse/Momentum: Can do shuffle board like competition. Compute similar items. Can use strategies of bouncy or sticky collisions to go target distance.
4. Rubber band/sling shot: Use what you know about elastic potential energy to see who can hit a target, etc. Compute the joules stored, the spring constant, etc. You can compete to see who can come closest to "actual" value. Can shoot at various angles with predicted values and see who comes closest.
5. Ball toss: Toss a tennis ball at varying angles by holding a hoop half way and requiring the ball to pass through the hoop's center, hit a target, compute the speed, KE, PE, launch angle, range. etc.
6. Vector treasure map: Start with particular floor tiles and have teams add vectors until they find the buried treasure. Have you forgot how to find resultants?
7. Spinning in circles: Put a (light-weight, soft) object in a bag. Tie it up and spin it around. Use circular motion knowledge to find the tension in the string based on mass, v, etc. Judge their time compared to yours and compete on accuracy and/or the ability to produce the same rotational speed without them using the clock (can they get the same value each time, etc.?)
8. Bouncing ball: Drop dead and fresh tennis balls or balls of various types and by letting it bounce just once, predict how many bounces before it stops bouncing. Find efficiency and the energy of deformation for a particular height. Estimate F, Δt, etc. using appropriate measurements or have participants figure it out on their own.
9. What's your idea? Don't limit yourself to these ideas. Certainly modify these in a way you like to have a good competition. Look on the internet, in books, talk to students from other physics classes in this school or your cousin in Texas. Originality may be worth a little bit too!

You will need to have some team point system and <u>some tie breaker in the event two teams tie</u> (no coin flips, something like...whoever handing in their paper first, or whoever came closes to estimating the ball height on the 3rd bounce, etc. Announce your tie breaker verbally, or write it on the board.

Test your ideas/events

Test! Test! Test!......You're best defense against a bad day when you're hosting is by testing your event idea and then getting the kinks out of it by modifying it. Make sure any questions or computations you have can be done in a reasonable amount of time and have an absolute time cutoff.

Don't hog a test....modify it instead!

Register your competitions with the teacher, but don't lock up and particular idea and then fail to use it! You can have some variations in events...we just don't want identical events every day. If you want, I can show you how to setup an Excel spreadsheet so you can come up with the "right" answer really fast to judge the competitors. This is what I do for grading some of your labs!

Test

Host teams will create a lab event and some kind of paper test with a key. The lab event must take no longer than 25 minutes from the time the bell rings (or the time announcements finish). The paper test should be graded fairly in plenty of time to post results on the board and give a paper copy to the teacher for record keeping. The teacher is there to help you create test questions, answers and advise you on the kind of questions to ask. Please however, do not ask for help the day of the competition itself, as this demonstrates less than optimal planning. Questions can be done with clickers instead of paper as an option. You may also ask questions orally and stop the test at any time if it takes too long or create a timed test.

<u>Bottom line</u>

Be reasonably ambitious. You can always add another event or do a few more questions if there is too much slack time. Be fair. Ask hard questions, but appropriate to what we're learning. Make the lab event challenging and fun, but not arbitrary. Be a good participant and odds are you. I will help you with ideas, suggestions, questions, solutions, but please ask me in person (not email) and don't do it on the same day as your competition.

Host form (due when bell rings on event day)

List the three competing teams in medal order and show how you computed point totals. If you needed to use a tie breaker, what tie breaker did you use (please try to post tie breaker on the board ahead of time)?

1st place team: Points = 9.5:

2nd place team: Points = 8.5:

3rd place team: Points = 7.5:

Sportsmanship medal

Best sportsmanship as a team (list one team or list none, team gets 1/2 pt extra):

Your rationale: What did they do compared to other two teams to earn this? (specific example, or no award)

Individual sportsmanship:

Up to two competing individuals for 1/2 pt each and include what they did to deserve the medal, examples include being helpful, honest/fair, demonstrating character in any way. Nobody can win more than one sportsmanship award and you must include for the teacher specifically what they did. In other words, "she was really fair", or "he helped out" won't do and no pts will be awarded. Specific examples: "she admitted she stepped over the line accidentally", or: "he picked up all the rulers and wiped the tables up too".

Individual medal winners:

Two individuals who did best at today's events (hosting team decides criteria and ideally announces it or posts it on the board: scored highest, fastest time, etc.). 1st place: 1 pt extra; 2nd place: 1/2 pt extra.

Team MVP:

Each team can pick a gold medal winner on their team for who did the most for them to do well today. It can be based on today's performance, or based on preparation to do well. The gold medal winner earns an additional pt. If you tell me two people are tied for MVP, they both get 1/2 pt. The decision of the team captain is final and due by the end of the period, or nobody gets an MVP award. It is suggested that the team captain confer with the team briefly and come to a conclusion as a team. YES, the team captain may select themselves as the MVP.

Unit 07 – Vocabulary and Equations – Circular motion, gravitation, torque & simple machines

Vocabulary:

previous vocabulary
circulation motion
simple machine
efficiency, ~~gravity, apparent weightlessness~~
centripetal, centrifugal, period, frequency
tangential speed, centripetal acceleration
centripetal force, circumference
~~g-force, black out, red out, klothoid loop~~
torque, rotate, revolve, banked curve, ~~geosynchronous orbit~~
lever arm (d sin(ɵ))
center of mass, axis of rotation
lever, inclined plane, pulley
right-hand rule
mechanical advantage (MA)
ideal mechanical advantage (IMA)
actual mechanical advantage (AMA)

Symbols:

a_c, v_t, F_c, τ

Equations & constants:

You get these on test:

$a = \Delta v/\Delta t$ $a_c = v^2/r$ $F_c = ma_c$ $v = x/t$

x = circumference = $2\pi r$ $\tau = Fd\sin(\Theta)$

$\tau_{net} = \Sigma\tau$ $W_{in} = W_{out}$ $MA = F_{out}/F_{in} = d_{in}/d_{out}$

$AMA = F_{out}/F_{in}$ $IMA = d_{in}/d_{out}$ Eff. = W_{out}/W_{in}

~~$F_g = \frac{G m_1 m_2}{r^2}$~~

Unit Objectives - Williams

1. I understand all the vocabulary & math of this unit and all demos, videos, equations, and class assignments.
2. I remember objectives & vocabulary from previous units.
3. I understand that circular motion requires a center-directed force
4. ~~I know what blackouts and red outs are and conceptually how coasters produce them and how klothoid loops are used to combat them~~
5. I can look at circular motion examples and identify the source of centripetal forces
6. I know the difference between centripetal force and centrifugal force (inertia) and which one is real
7. I can use basic geometry knowledge to help solve circular motion problems
8. ~~I know the inverse square (gravity) and the inherent relationships therein and this law is common in physics~~
9. ~~I know the important distance for gravity is the distance between centers of mass~~
10. ~~I understand the law of gravitation and gravity is a relatively weak force, but is only capable of attraction~~
11. ~~I know that a normal force is required to feel weight as experienced in elevators and by astronauts~~
12. ~~I understand what torque is and can distinguish between torque and force~~
13. I understand that a lever arm is not the same as a length, but a kind of perpendicular length
14. I can describe how the length of a lever arm affects how much torque can be generated
15. I understand that torque is a factor and I can use the right-hand rule to determine its sign
16. I can compute torque, including sign, and find net torque when two or more forces are providing torque
17. I understand the fundamental principle of simple machines: trading force for distance
18. I can identify three kinds of simple machines: lever, inclined plane, and pulley
19. I know what mechanical advantage is and understand the difference between actual mechanical advantage and ideal mechanical advantage
20. I understand the concept of efficiency and how it relates to friction, AMA, IMA, F_{out} and F_{in}

DuPage ROE Objectives

211. I can identify the direction of the velocity, acceleration, and net force on an object undergoing uniform circular motion.

Physics Calendar - Circular motion & simple machines: 2013-14(Williams) - Chapters 7 (12/27 days)

Bold and underlined means put in journal notes (for any problems: Show your work!);

1	Mo:11/25/13	GOALS: a_c is toward center, ABS brakes, how fast or how tight of a circle? • Water bottle in motion: Class demo/lab • Group Quiz or HW time: problems: R_{min}, V_{max}, μ_{min}	• **<u>(07-01)</u>** Notes: Circular motion & centripetal acceleration/force:**5,6,7** • **<u>(07-02)</u>** p 236: 1-4; p 238: 1-4
2	Tu:11/26/13	GOALS: Cars going over hills: mg > F_N, the difference between them if $F_c = ma_c$. ….IT IS ACCELERATING! • Clix? Present car over hill • Coaster and car examples	• R07-01 sheet (custom problem sheet)
3ED	We:11/27/13 11:30 dism	GOALS: Reinforce previous lessons • Clix, go over HW, Quiz?	• **<u>(07-03)</u>** Notes: skip gravitation: **12,13,14,15,16,21**
4L	Mo:12/02/13	GOALS: Review, introduce torque • Clix/go over HW • What is torque, simple force/torque balances problems • Torque lab	• R07-02 sheet
5	Tu:12/03/13	GOALS: Harder torque problems - pick simplest pivot point • Go over harder problems, sitting on a swing, flags, etc.	• R07-03 sheet
6	We:12/04/13	GOALS: Review unit concepts thus far • Recap, group quiz	• R07-04 sheet
7	Th:12/05/13	GOALS: Introduce simple machines • Go over quiz? Intro simple machines	• **<u>(07-05)</u>** Notes: skip coasters, simple machines: trading force for distance!:**4,17,18,19,20** • R07-05 sheet
8	Fr:12/06/13	GOALS: Simple machines lab and problems, IMA, AMA, eff. • MA problems: Work in = Work out	• R07-06 sheet
9	Mo:12/09/13	GOALS: Simple machines lab: F_{in}, F_{out}, d_{in}, d_{out}. • Do simple machines lab, or Inclined plane lab	• **<u>(07-06)</u>** p 261: 1-3, 5-7; • p. 263+: 2,8
10	Tu:12/10/13	GOALS: Group activity • Clix, Group quiz (go over tomorrow)	• **<u>(07-07)</u>** p. 263+: 3,9,11,35
11L	We:12/11/13	GOALS: Review for test, class choice, or make up day	• Study for test
12	Th:12/12/13	• Circular motion & simple machines Exam	• Family time!
13	Fr:12/13/13	• Introduce Olympics project/ROE 10 pt test on 1/10/14	• Work on project
14	Mo:12/16/13	Final exam review day/Work on Olympics	• Final review sheet?
15	Tu:12/17/13	Final exam review day/Work on Olympics	• Work on project
16	We:12/18/13	Final exam review day/Work on Olympics	• Final review sheet?
17	Th:12/19/13	Final exam review day/Work on Olympics	• Work on project
18	Fr:12/20/13 Winter Break!	• Possible small EC opportunity, study for Final	• HAPPY VACATION!
19	Mo:01/06/14	• Group 1: Olympics	• Study for Final
20	Tu:01/07/14	• Group 2: Olympics	• Study for Final
21H2	We:01/08/14	• Group 3: Olympics	• Study for Final
22	Th:01/09/14	• Group 4: Olympics	• Study for Final
23	Fr:01/10/14	• ROE post-semester exam (up to 10 EC pts on final)	• Study for Final
24	Mo:01/13/14	• Final exam review (can't go over ROE)	• Study for Final
Finals	Tu:01/14/14	• Periods 3, 4/5 (1 PM dismissal)	• See you next semester!
Finals	We:01/15/14	• Periods 2, 10, 7/8 (1 PM dismissal)	•
Finals	Th:01/16/14 End of Sem1	• Periods 1, 9 (done @ 11:15, except make-ups)	• Teacher's institute so no school for YOU!