GreatHearts

Physics I

April 6 – April 9

Time Allotment: 40 minutes per day

Student Name: ___________________________________

Teacher Name: ___________________________________

Physics I
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Packet Overview

Date	Objective(s)	Page Number
Monday, March 23	1. Review Angular Quantities. 2. Finish Discussion on Torque	2-4
Tuesday, March 24	1. Torque Practice Problems	5-6
Wednesday, March 25	1. Introduce Rotational Dynamics 2. Connect F = ma to $\tau = I\,\omega$	7-9
Thursday, March 26	1. Introduction to Moment of Inertia	10-11
Friday, March 27	Off	

Additional Notes: The guided worksheets in this packet will follow the textbook readings from Giancoli found at the end of the packet. The final page of this packet will contain an answer key for all Problems and answers to quiz questions.

Khan Academy is a great online resource for physics, though this packet does not require access to the Internet. The Physics videos can help with rotational motion concepts, while the algebra and geometry videos can help with the concept of radians.

Another great resource is a YouTube channel called "Doc Schuster". Dr. Schuster is a high school physics teacher in St. Louis who makes great video lectures with magic markers and paper. His playlist "AP Ch 10 – Rotational Motion and Energy" will be a good review of what we covered in previous packets. This week, "AP Ch 11 – Rotational Mechanics and Torque" will be helpful.

Finally, if you're wanting to see the bigger picture and put all of these concepts together at the college level, Walter Lewin's Freshman Physics MIT lectures are as good as they get. Dr. Lewin is so talented at engaging students and preparing exciting demos to add to the lectures. Search on YouTube for "8.01x Lect 19 Walter Lewin" to watch the beginning of his lectures on rotational motion.

Academic Honesty

I certify that I completed this assignment independently in accordance with the GHNO Academy Honor Code.

Student signature:

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I certify that my student completed this assignment independently in accordance with the GHNO Academy Honor Code.

Parent signature:

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Monday, April 6

Physics Unit: Rotational Motion
Lesson 1: Torque
Requirements: Read p. 204-205 in the textbook provided in the back of the packet and complete the worksheet below.

Unit Overview: Rotational Motion
Once again, in this unit we will be taking what we have already learned about linear velocity, acceleration, and momentum, and apply them to rotational cases. This will be different from our Chapter 5 unit on circular motion, because as you remember, objects in that chapter orbited in circles (think about the tennis ball on the string and the Moon orbiting around the Earth). In this chapter, we will be concerned with the rotation of the bodies themselves. These rotating bodies can be anything from a penny spinning on its side, you and your friends riding a Merry-Go-Round, a planet making its daily rotation, or an electron spinning. You should be getting excited! Towards the end of this chapter, we will get to see how the fundamentals of rotational motion we will learn leads to one of the most stunning demonstrations in all of mechanics. Stay tuned.

Lesson 1 Objective: Be able to do this by the end of this lesson.
1. Demonstrate that you have memorized all angular quantities and their conversions to and from their linear analogs.
2. Define toque. Draw diagrams labelling the components of torque.
3. Solve torque problems.

Introduction to Lesson 1
First we'll do a quick review of Section 8-1. You can't study that section enough. The better you know these quantities and their conversions, the easier learning torque and angular momentum, our new topic for this week, will be. Second, we'll spend the rest of our time going through example problems and get some practice setting up and solving torque problems.

Questions to ponder:
How is torque like work? How is it different? Is torque a force? How is it similar to or different from force? Can Newton's laws account for torque, or are you expecting a surprise 4th Law of motion with reference to torque?

1. Review from last week. Remember these quantities? Complete the equation for each of these.

$\theta = l / r$

$\omega = \Delta\theta /$

$\alpha =$

2. Converting from angular to linear quantities. For each linear quantity, write what it equals in terms of its angular sibling. The first two have been done for you.

$l = r\,\theta$

$v = r\,\omega$

$a =$

$\theta =$

$\omega =$

3. In your own words, define torque.

4. Draw and label a diagram of a force applying a torque to an object. You can get creative and come up with your own or use one from the textbook.

5. Write the equation for torque.

6. In the space below, write the question, draw the diagram, and work all steps for Example 8-8: Biceps Torque on p. 205.

7. In the space below, work **Exercise B** on p. 205.

8. In the space below, write the question, draw the diagram, and work all steps for Example 8-9: Torque on the compound wheel on p. 205 and have a great day.

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Tuesday, April 7

Physics Unit: Rotational Motion
Lesson 2: Torque Practice Problems
Requirements: Do Problems 22-24 on p. 220.

Objective: Be able to do this by the end of this lesson.
1. Apply concepts of torque to solve problems.

Introduction to Lesson 2
Now we're going to work on our torque problem-solving skills today!

But, before we begin, once again, in the space below, write the 4 linear and 4 rotational kinematic equations of motion one time. You can make a table like the one in Section 8-2 in your book to stay organized.

p. 224 (22-24)
1: Draw and label a diagram.
2: Write down your knowns and unknowns.
3: Write down the equations you need.
4: Solve algebraically for the variable you're looking for.
5: Show all steps for full credit.

22)

23)

24)

Wednesday, April 8

Physics Unit: Rotational Motion
Lesson 3: Torque and Rotational Inertia
Requirements: Read p. 206-207 and fill in the worksheet below.

Objective: Be able to do this by the end of this lesson.
1. Distinguish linear acceleration from rotational acceleration.
2. Distinguish torque from force.
3. Define rotational inertia and distinguish it from mass.

Introduction to Lesson 3
Today we are going to compare force with torque and mass with a new quantity called rotational inertia (or moment of inertia). The question to think about as you read and answer these questions that follow is how closely related are force and mass with torque and rotational inertia. Can Newton's 2^{nd} Law of Motion account for torque and rotational inertia?

8-5 Rotational Dynamics; Torque and Rotational Inertia

For full credit, write in complete sentences.

1) What is the definition of dynamics? How is it different from kinematics? (You may have to flip back to earlier chapters we've studied in your book if you don't remember.)

2) Write down Newton's Second Law for translational motion.

3) In Newton's Second Law, _______ is proportional to ______. But now, _____________ has taken the place of ________________, and , correspondingly, the ____________________________ takes the place of ____________________________.

4) The equation for linear acceleration is a = .

5) α is proportional to __________.

6) Your response to 5) follows directly from Newton's second law, ____________________.

7) In the space below, draw and label Figure 8-18.

8) What is the torque that gives rise to the angular acceleration in the figure above?

9) What is the equation that relates angular acceleration to tangential linear acceleration?

10) If we take that equation and plug in $r\alpha$ for tangential linear acceleration in $F = ma$, write the equation we get:

$F =$

11) When we multiply both sides of this equation by r, we find that the torque is given by what equation?

12) Here we have a direct relation between the angular acceleration and the applied torque. The quantity

___________ represents the ______________________ of the particle and is called its

______________________________.

13) Equation 8-12 essentially tells us $\Sigma\tau = (mr^2)\alpha$. Once again, what is mr^2?

14) Equation 8-13 basically tells us that $I = mr^2$. What is I?

15) What equation do we get if we combine Equation 8-12 and Equation 8-13? This is the rotational equivalent of Newton's second law.

16) We see that rotational inertia (also called moment of inertia) plays the same role for rotational motion

that ________________ does for translational motion.

17) The main difference between mass and rotational inertia is that the rotational inertia of an object

depends not only on its mass, but also on __________________________________.

18) Why will a large diameter cylinder have greater rotational inertia than one of equal mass but with a smaller diameter?

*Rotational inertia and moment of inertia are the same thing. Your textbook uses both terms interchangeably. I think rotational inertia makes more intuitive sense and is easier to understand, therefore, I will always refer to the quantity *I* as rotational inertia. Let me know if you have any questions about this distinction. Have a great Wednesday!

Thursday, April 9

Physics Unit: Rotational Motion
Lesson 4: Quiz on Rotational Inertia
Requirements: Study for quiz, then take Quiz.

Objectives: Be able to do this by the end of this lesson.
1. Demonstrate mastery of torque as introduced in this packet.
2. Demonstrate mastery of our introduction to rotational inertia.

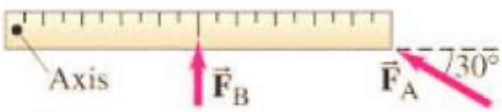
Introduction to Lesson 4: Today we're going to wrap up our week with a quiz. Spend 10-15 minutes reviewing your packet for this week, and then 25-30 minutes taking the quiz.

Physics I – Quiz on Torque and Rotational Inertia

Name: ______________________________

1) Define torque. Write the equation for torque.

2) Two forces (F_B = 20N and F_A = 30N) are applied to a meter stick which can rotate about its left end. Force F_B is applied perpendicularly at the midpoint. Which force exerts the greater torque?



3) $\Sigma\tau = (mr^2)\alpha$. What is mr^2 called?

4) We see that ______________________________ plays the same role for rotational motion

that ________________ does for translational motion.

5) Write the rotational equivalent of Newton's second law.

Answer Key

Lesson 1

Exercise B on p. 205: F_A

Lesson 2
p. 220 (Problems 22-24)

22)

(A) Radius of circle $(r) = 0.17\,m$

Mass of person $(m) = 55kg$

Maximum torque exerted $\tau = F \times r$

$= mg \times r$

$= (55 \times 9.8 \times 0.17)mN$

$\boxed{\tau = 92\,m\,N}$

(B) She could exert more torque by pushing down harder with her legs, raising her center of mass. She could also pull upwards on the handle bars as she pedals, which will increase the downward force of her legs.

23) a) τ = 40.7 N m

b) τ = 29 N m

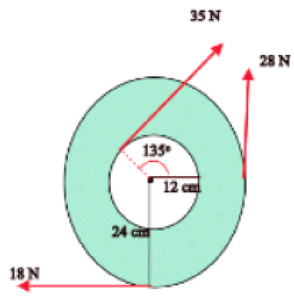
24)

Torque is defined as the product of the force and the perpendicular distance between the rotation axis and the point of application of the force,

$$\tau = rF\sin\theta$$
$$= r_{\perp}F$$

Here, F is applied force and $r_{\perp}$ is perpendicular distance.

The following is the figure of a wheel which is acted upon by different forces.



In the above figure, three forces of different magnitudes are being acted on the wheel at different distances from the axis of rotation. Let the forces of magnitude 18 N, 28 N and 35 N be F_1, F_2 and F_3.

Convert the distances from the axis of rotation from cm to m.

$$r_1 = (12\text{ cm})\left(\frac{1\text{ m}}{100\text{ cm}}\right)$$
$$= 0.12\text{ m}$$
$$r_2 = (24\text{ cm})\left(\frac{1\text{ m}}{100\text{ cm}}\right)$$
$$= 0.24\text{ m}$$

Assume that counterclockwise torques as positive and clockwise torques as negative.

Calculate the torque on the wheel about the axle of the wheel due to three applied forces.

$$\tau_{\text{Applied forces}} = -F_1r_2 + F_2(2r_1) - F_3(r_1) \qquad \ldots\ldots (1)$$

Substitute 18 N for F_1, 28 N for F_2, 35 N for F_3, 0.12 cm for r_1, and 0.24 m for r_2 in equation (1).

$$\begin{aligned}\tau_{\text{Applied forces}} &= -(18\text{ N})(0.24\text{ m})+(28\text{ N})(2(0.12\text{ m}))-(35\text{ N})(0.12\text{ m})\\ &= -4.32\text{ N}\cdot\text{m}+6.72\text{ N}\cdot\text{m}-4.2\text{ N}\cdot\text{m}\\ &= -1.8\text{ N}\cdot\text{m}\end{aligned}$$

Negative sign indicates that the torque due to the applied forces is in the clock wise direction.

Frictional always opposes the motion of the object. Since, the net torque on the object is In the clockwise motion, the frictional torque f_{torque} will be counterclockwise.

Calculate the net torque about the axle of the wheel.

$$\tau_{\text{net}} = -\tau_{\text{Applied forces}} + f_{\text{torque}}$$

Substitute $-1.8\text{ N}\cdot\text{m}$ for $\tau_{\text{Applied forces}}$ and $0.40\text{ N}\cdot\text{m}$ for f_{torque}.

$$\begin{aligned}\tau_{\text{net}} &= -1.8\text{ N}\cdot\text{m}+0.40\text{ N}\cdot\text{m}\\ &= -1.4\text{ m}\cdot\text{N}\end{aligned}$$

Negative sign indicates that the net torque on the wheel is in the clock wise direction.

Therefore, the net torque about the axle of the wheel is $\boxed{1.4\text{ N}\cdot\text{m}}$.

Answer Key for April 9 Quiz

1) Answers may vary for definition of torque. Equation: $\tau = F\, r \sin\theta$.

2) F_A

3) Rotational Inertia.

4) We see that **<u>rotational inertia</u>** plays the same role for rotational motion that **<u>mass</u>** does for translational motion.

5) $\Sigma\tau = I\,\alpha$

Email if you have any questions!