Unit Cover Page

Unit Title: Laws of Motion **Grade Level: 12th**

Subject/Topic: Laws of Motion

Key Words: Newton's Laws, friction, impulse, momentum, rotational loads, centripetal force

Standards/Indicators:
EALR 4)Physical Sciences - Force and Motion
9-11 PS1D A net *force* will cause an object to *accelerate* or change direction. A less massive object will *speed* up more quickly than a more massive object subjected to the same *force*. (Newton's Second Law of Motion, F=ma)

EALR 4)Physical Sciences - Force and Motion
9-11 PS1 E - Whenever one object exerts a force an another object, a force of equal magnitude is exerted on the first object in the opposite direction. (Newton's Third Law of Motion)

Designed by: Akwetee Watkins **Time Frame: three weeks (mid year)**

Brief Summary of Unit (including curricular context and unit goals):
This unit introduces students to the laws of motion and calculations of forces. Focus areas include study of friction, momentum, impulse and rotational loads. The goal is to tie theory to practical application. Context is provided by the sample problems that include car safety and turbine engine applications. In addition, we include community by once a month having a parent or community members, who works with a related technology, speak in class.

Unit Design Status: ☒ Completed template pages – Stages 1, 2, and 3

☒ Completed blueprint for each performance task ☒ Completed rubrics

☒Directions to students ☒ Materials and resources listed

☐ Suggested accommodations ☐ Suggested Extensions

Status: ☒ Initial Draft (date: 11/19/10) Revised draft (date:)
☒Peer Reviewed ☐Content reviewed ☐Field Tested ☐Validated
☐Anchored

Stage 1- Identify Desired Results

Established Goals:

Standard / Indicators: Washington State EALRs

EALR 4) Physical Sciences - Force and Motion
9-11 PS1D A net *force* will cause an object to *accelerate* or change direction. A less massive object will *speed* up more quickly than a more massive object subjected to the same *force*. (Newton's Second Law of Motion, F=ma)

EALR 4) Physical Sciences - Force and Motion
9-11 PS1 E - Whenever one object exerts a force on another object, a force of equal magnitude is exerted on the first object in the opposite direction. (Newton's Third Law of Motion)

What essential questions will be considered?	**What understandings are desired?**
	Students will understand that…
1) How does mass and rotational speed affect rotational forces?	1) Rotational forces are related to the square of speed
2) What affect does acceleration have on impact loads?	2) Impact loads are directly proportional to acceleration
3) How do we calculate velocities after impact?	3) Conversation of momentum can be used to calculate speed after impact
4) What are the variables that affect friction?	4) Frictional force is directly proportional to weight of object

What key knowledge and skills will students acquire as a result of this unit?

Students will …	*Students will be able to…*
• Given mass, velocity, and time information, students will be able to use Newton's second law of motion to calculate impulse loads. Students will demonstrate understanding by cooperatively completing a lab that measures and calculates impulse loads due to changes in acceleration. F= m a = m (delta v / t)	• Based on Newton's 2nd law, students will be able calculate the centripetal force on objects moving in a circle. Students can explain the how mass, velocity and radius affect rotating loads. $$F = ma = \frac{mv^2}{r} = mr\omega^2$$
• Given mass and velocity, students will be able to calculate the momentum of moving objects: P=m*v. Using the principles of	• Students will be able to calculate the force due to friction and the coefficient of friction. Students can explain the difference between coefficient of static and sliding

conservation of momentum, students will demonstrate understanding by cooperatively completing a lab that measures and calculates velocities after impact. $m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$	friction. **F=uN**

Stage 2- Determine Acceptable Evidence

What evidence will show that students understand?

Performance Tasks:
Summative Assessment Four completed lab reports will serve as the evidence of student learning. Though the lab is done as a group, each student completes his/her own report. A rubric for lab reports has been provided to students. Rubric includes assessing: Purpose, Diagrams, Procedures, Notebook, Calculations, Analysis, and Conclusions There will also be quiz approximately every week. Quiz will include both selected response items (25%) and extended response items (75%).

What other evidence needs to be collected in light of Stage 1 Desired Results?

Other Evidence (e.g., tests, quizzes, prompts, work samples, observations)

Formative assessments
• Warm-Up Exercise are used to introduce each lesson. The subsequent discussion allows students to connect to prior learning and teacher to asses prior knowledge. Example questions include:
  • Impulse - What are the differences in loads between the car crash and the engine test video?
  • Momentum - Using Newton's Second Law, F = ma, explain why it is important to wear your seatbelt.
  • Centripetal Loads - Why do you not fall out of your seat when you are upside down on a roller coaster?

- Friction - Is it better to slam on the brakes and skid to a stop OR apply the brakes slowly and don't skid? Why?

- Also, group quizzes will be used as a formative assessment.

Student Self-Assessment and Reflection:

- At end of class, 'Exit Slips' are written by each student on note cards. In one or two sentences they answer, "One thing I learned and one question I have..."

- Students will reflect in lab reports. Report includes a conclusion section that asks students to reflect on whether findings support hypothesis, possible sources of error and what was learned.

Stage 2- Determine Acceptable Evidence (continued)

Assessment Task Blueprint

What understandings or goals will be assessed through this task?

To increase student understanding of how friction affects daily life by exploring how friction is affected by physical variables. Physical variables include different materials, orientations, and lubrication.	

What criteria are implied in the standards and understandings regardless of the task specifics?	**What qualities must student work demonstrate to signify that standards were met?**
EALR 4)Physical Sciences - Force and Motion 9-11 PS1 E - Whenever one object exerts a force on another object, a force of equal magnitude is exerted on the first object in the opposite direction. (Newton's Third Law of Motion)	Illustrate with every day examples that for every action there is an equal and opposite reaction. Student's lab will demonstrate that students can apply balance of forces as it relates to friction.

Through what authentic performance task will students demonstrate understanding?

Friction Lab – Finding Coefficient of Static Friction

Materials Needed: Protractor, sliding blocks (wood, rubber, metal), water, vegetable oil, wooden board

Procedure:
1. Measure weight of block
2. Place the wooden blocks on the wooden board. Increase the angle of the board until the block starts to slide.
3. Using protractor, measure angle of board when block started to slide.
4. Compute the normal force and the maximum static friction force from your measurements.
5. Repeat this procedure for the other blocks and materials.
6) Using the computer at each lab station graph the coefficient of friction and normal force for each material combination.

What student products and performances will provide evidence of desired understandings?

Friction Lab Report

Key Questions:

1) What is the relationship between the maximum static friction force and the normal force?

2) What is the influence of the type of material on the maximum static friction force?

3) How would you summarize the affect of adding water or vegetable oil to the sliding blocks?

By what criteria will student products and performances be evaluated?

Review Rubric

-Though the lab is done as a group, each student completes his/her own report.

-Rubric includes assessing Purpose, Diagrams, Procedures, Notebook, Calculations, Analysis, and Conclusions

-See rubric below.

Student Name: _____

CATEGORY	4	3	2	1
Question/Purpose	The purpose of the lab or the question to be answered during the lab is clearly identified and stated.	The purpose of the lab or the question to be answered during the lab is identified, but is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is partially identified, and is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is erroneous or irrelevant.
Drawings/Diagrams	Clear, accurate diagrams are included and make the experiment easier to understand. Diagrams are labeled neatly and accurately.	Diagrams are included and are labeled neatly and accurately.	Diagrams are included and are labeled.	Needed diagrams are missing OR are missing important labels.
Procedures	Procedures are listed in clear steps. Each step is numbered and is a complete sentence.	Procedures are listed in a logical order, but steps are not numbered and/or are not in complete sentences.	Procedures are listed but are not in a logical order or are difficult to follow.	Procedures do not accurately list the steps of the experiment.

Journal/Notebook	Clear, accurate, dated notes are taken regularly.	Dated, clear, accurate notes are taken occassionally.	Dated, notes are taken occassionally, but accuracy of notes might be questionable.	Notes rarely taken or of little use.
Calculations	All calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results labeled appropriately.	No calculations are shown OR results are inaccurate or mislabeled.
Analysis	The relationship between the variables is discussed and trends/patterns logically analyzed. Predictions are made about what might happen if part of the lab were changed or how the experimental design could be changed.	The relationship between the variables is discussed and trends/patterns logically analyzed.	The relationship between the variables is discussed but no patterns, trends or predictions are made based on the data.	The relationship between the variables is not discussed.
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.

Source: Rubistar

Stage 3- Plan Learning Experiences

WHERETO

What sequence of teaching and learning experiences will equip students to engage with, develop, and demonstrate the desired understandings? Use the following sheet to list the key teaching and learning activities in sequence. Code each entry with the appropriate initials of the WHERETO elements.

1. Students watch 5 minute video of car crash and aircraft engine tests video (H, E-1)
2. Discussion of car crash and aircraft engine tests video. The group discussion asks the students to explain the change in forces seen. (W, R)
3. Review Objective: Given mass, velocity, and time information, I can calculate impulse loads. (O)
4. Students will observe a teacher calculating impulse loads using Newton's Laws. F= m a = m (delta v / t) (W,T)
5. Discussion: Why does it make sense to where a seat belt in this scenario? (R)
6. Cooperatively completing a lab that measures and calculates impulse loads due to changes in acceleration. F= m a = m (delta v / t). Though the lab is done as a group, each student completes his/her own report including measured data on impact loads, and calculated results using Newton's Laws of Motion. (E-2,T)

7. Upon Entering class students do 'Warm Up' exercise while teacher takes attendants and sets up demonstration. Question is, "Based on previous lesson on impulse loads, why is it important to wear your seatbelt?" (W, E-2)
8. Teacher answers 'Warm Up', using F=ma=m*(Δv/Δt) (O)
9. Review Objective: Given mass and velocity, I can calculate the momentum of moving objects, Using conservation of momentum, I will complete a lab that measures and calculates velocities after impact. (O)
10. Group discussion of 5 minute train / car momentum video. Did the train slow down after impact? What do you think would happen if car weighed more? (H, E-1,W,R)
11. Students will observe a teacher calculating change in velocity using principle of Conservation of Momentum. $m_{projectile}v_{projectile} = m_{cannon}v_{cannon}$ (W,T)
12. Discussion: What would happen if you doubled the velocity of the projectile? (R)
13. Teacher introduces momentum lab that uses carts on rails to calculate velocity after impact. Class and teacher performs sample calculation using, $m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$ Class writes down notes and types numbers into calculators (E-2,T)
14. Cooperatively completing a lab that on an air track moves and impacts two carts. Though the lab is done as a group, each student completes his/her own report. Including measure and calculation final velocity after impact. After the measurements are made, students compare them to theoretical calculations using Conservation of Momentum. (E-1, E-2,T)
15. Review objectives and summarize key points about Conservation of Momentum: Given mass and velocity, we can calculate the momentum of moving objects, P=m*v. Conservation of Momentum -the momentum of two objects after the collision will be the same as the momentum of two objects before the collision. After impact, for two objects we can calculate velocities. $m_1v_1 + m_2v_2 = m_1v'_1 + m_2v'_2$ (O)

16. Exit Slips' - "One thing I learned and one questions I have.." (R)

17. Upon Entering class students do 'Warm Up' exercise while teacher takes attendance and sets up video. Question is" Why do you not fall out of your seat when you are upside down on a roller coaster?" (W, E-2)
18. Review Objective: I can calculate the centripetal force on objects moving in a circle. I can explain the how mass, velocity and radius affect rotating loads. (O)
19. Discussion of current news story of jet engine that blew up. Group discussion of jet engine tests video / news report. What variables affected rotational force? (W, R)
20. Teacher will show actual engine parts. (H,T)
21. Based on actual jet engine loads students will observe a teacher calculating Centripetal forces using Newton's 2nd law. Class writes down notes and key equations. Discussion: If loads are too high for the engine, and any variable could be lowered by 10%, which should be lowered? (W,T)
22. Centripetal forces on a car. Using calculators, class solves problem along with the teacher. (E-2,T)
23. Discussion: What would happen if you doubled your speed? (R)
24. Teacher introduces rotational loads lab that uses swinging weights. Cooperatively students measure the effect of speed on centripetal force. Keeping radius of the circle constant while whirling the object. Students will vary the speed of mass and calculate, measure, and graph the force. (E-2,T)
25. Review objectives points about Centripetal force. According to Newton's 2nd Law, an object's "natural state of motion" is to *continue in linear, uniform motion*. In order for an object to move in a *circular* path, Centripetal force is needed to pull it away from the straight-line trajectory it "wants" to follow(O)
26. 'Exit Slips' - "One thing I learned and one questions I have.." (R)

27. 'Warm Up' exercise while teacher takes attendance and sets up video. Question is" Is it better to slam on the brakes and skid to a stop OR apply the brakes slowly and don't skid? – Why? (W, E-2)
28. Review Objective: I can calculate the force due to friction and the coefficient of friction. I can explain the difference between coefficient of static and sliding friction (O)
29. Discussion of answer to "Warm - Up" and friction 1 minute friction video (W, R)
30. Friction Theory F=uN (W,T)
31. Friction Demonstration – "coin sliding on book"; Teacher works sample question, with students using their calculators. "What is coefficient of static friction between book cover and coin?" (H,T)
32. Students using their own coin and book calculate coefficient of static friction. Teacher walks to each student and checks for understanding. After 10 minutes, the teacher answers some frequently asked questions on the board. (E-2,T)
33. *Friction Lab – Finding Coefficient of Static Friction*: To gain a better understanding of friction by exploring how friction is affected by physical variables. Questions: What is the relationship between the maximum static friction force and the normal force? What is the influence of the type of material on the maximum static friction force? How would you summarize the affect of adding water or vegetable oil to the sliding blocks. (E-1, E-2,T)
34. Review objectives and summarize key points about Friction force. I can calculate the force due to friction and the coefficient of friction using the equation F=uN. I can explain the difference between coefficient of static and sliding friction. (O)
35. 'Exit Slips' - "One thing I learned and one question I have.." (R)

Stage 3- Plan Learning Experiences (continued)

Consider the WHERETO elements. (See Calendar on following page.)

Monday	Tuesday	Wednesday	Thursday	Friday
1. Watch 5 minute video of Car Crash and Aircraft engine tests video and discussion (H, E1) **2.** **Review Objective**: Given mass, velocity, and time information, I can calculate impulse loads. (O) 3. Students will observe a teacher calculating impulse loads using Newton's Laws. F= m a = m (delta v / t). Discussion (W,T,R)	4. Cooperatively completing a lab that measures and calculates impulse loads due to changes in acceleration. F= m a = m (delta v / t).(E-2,T)	**5.** 'Warm Up' exercise "why is it important to wear your seatbelt?" (W,E-2) 6. **Review Objective:** I can calculate the momentum of moving objects. (O) 7. Discussion train / car momentum video. (W)	8. Teacher calculating change in velocity using principle of Conservation of Momentum. Discussion (W,R,T) 9. Introduce momentum lab that uses carts on rails to calculate velocity after impact. (E-2,T)	10. Cooperatively completing a lab that on an air track moves and impacts two carts. - Conservation of Momentum. (E-2,T) **11.** Exit Slips' - "One thing I learned and one questions I have.." (R)
12. Quiz on Impulse and Momentum (E-2)	13. 'Warm Up' "Why do you not fall when you are upside down on a roller coaster?" (W,E-2) 14. **Objective**: calculate the centripetal force on objects (O) 15. Discussion of news story of jet engine 16. Teacher calculating Centripetal forces Discussion: (W,T,R))	**17.** Centripetal forces on a car. Using calculators, class solves problem along with the teacher. Discussion (E-2,T)	18. Rotational loads lab that uses swinging weights. -centripetal force. (E-2,T) 19. 'Exit Slips' - "One thing I learned and one question I have.." (R)	20. Quiz on Rotation Loads (E-2)
21. **Objectives.** I can calculate the force due to friction and the coefficient of friction using the equation F=uN. (O) 22. Discussion of answer to "Warm - Up" and friction 1 minute friction video (H, E1) 23. Friction Theory F=uN and Discussion (E-2,T)	24. Review, Friction Theory F=uN and Discussion (E-2,T) 25. Friction Demonstration – "coin sliding on book" (E-2,T)	26. Students using their own coin and book calculate coefficient of static friction. Teacher checks for understanding. Teacher answers some frequently asked questions on the board. (E-2,T)	27. *Friction Lab – Finding Coefficient of Sliding Friction***:** **e**xploring how friction is affected by physical variables. (E-2,T) 28. 'Exit Slips' - "One thing I learned and one question I have..	29. Quiz on Friction