

HOW MUCH FORCE IS REQUIRED TO PULL A LARGE OBJECT UP AN INCLINE?

Performance Standard (6B/7C/9D).J

Calculate and measure the force needed to pull an object on a flat surface and then an incline using a set of formulas, angle measures and instrument measurements:

- *Mathematical knowledge*: know the relationships between sin, cosin, tangents.
- *Strategic knowledge*: use appropriate strategies to apply formulas and geometric properties of triangle.
- *Explanation*: explain completely and clearly what was done and why it was done.

Procedures

1. *In order to investigate, represent and solve problems using number facts, operations and their properties, algorithms and relationships (6B); select and use appropriate technology, instruments and formulas to solve problems, interpret results and communicate findings (7C); and use trigonometric ratios and circular functions to solve problems (9D)*, students should experience sufficient learning opportunities to develop the following:

- Develop fluency in operations with real numbers, vectors and matrices using mental computation or paper-and-pencil calculations for simple cases and technology for more-complicated cases.
- Solve practical problems using non-linear scales.
- Solve problems using vectors.
- Relate vector representations and trigonometric functions.

A technician in the workplace may need to know how much force it would take to pull a large box up an incline. After calculating the force the technician will be able to determine the type of equipment needed to perform the task.

2. Provide each student a copy of the “How Much Force Is Required to Pull a Large Object Up an Incline?” task sheet and the rubric. Have each team discuss the project in Figure 1 of the student task sheet.
 - a. Determine the coefficient of sliding friction on a horizontal plane. (Figure 1 shows the material and set-up needed to complete this task.) Show all your calculations and explain your work.
 - b. Use the value you calculated for the coefficient of friction in Part A to help determine the amount of force needed to slide the object up a ramp (made of the same material as the horizontal plane) with an angle of elevation of 25° . Have students review and discuss the task to be completed and how the rubric will be used to evaluate it.
3. Have the students work in teams of 2 – 4 students. Materials should be available from the science department, if you do not have them in your classroom. Students should have experience and knowledge about how to determine the coefficient of friction prior to this assessment. Students should specifically had experience with calculating the coefficient of friction, normal forces and the relationship between the angles of elevation and the amount of force required to move an object. Discussing the use of vectors to represent forces is also helpful to students prior to taking this assessment.
4. Evaluate each student’s work using the rubric and its guide to determine the performance level. Give each student a score in each of the three categories, scoring each part of the problem separately. Minor errors in computation include making errors in the actual addition or multiplication or rounding incorrectly. Major errors include using the wrong operation or formula. The explanations should include how they found these answers as well as why these answers are correct.

The key idea here is for students to understand linear and/or nonlinear relationships well enough to apply them to a practical situation. The students should use trigonometry to calculate the normal force (N) for the given angle of elevation and may use vectors to represent the forces present in the problem. This problem is not asking for the total work done in moving the block along the incline plane, just the amount of force needed to make it move.

Examples of Student Work

- [Meets](#)
- [Exceeds](#)

Time Requirements

- Two class periods

Resources

- Copies of the “How Much Force Is Required to Pull a Large Object Up an Incline?” task sheet
- Calculator
- Protractor
- Graph paper
- One block of wood or other material
- One, two-foot board or other material for ramp
- Spring scale
- Mathematics Rubric

HOW MUCH FORCE IS REQUIRED TO PULL A LARGE OBJECT UP AN INCLINE?

Use Figures 1 & 2 and the given formulas to help answer each question.
Show all your work and explain your reasoning.

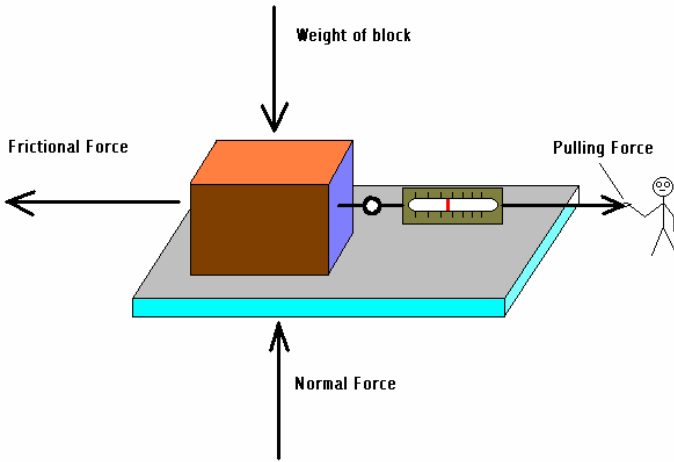


Figure 1*

$$\mu = f / N$$

where:

μ = Coefficient of friction between the materials
 f = force of friction
 N = normal force (equal to object weight on a horizontal plane or determined by the following formula on an inclined plane.)

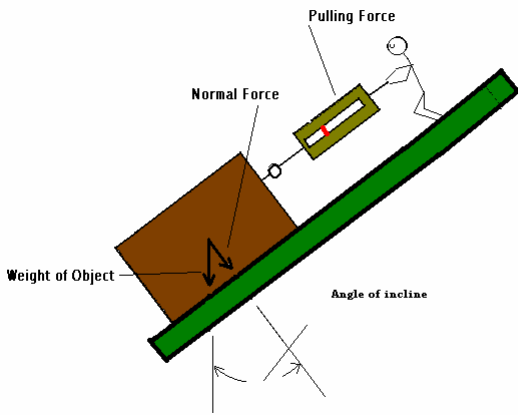


Figure 2*

And $N = W / \cos \theta$

where:

W = objects weight
 θ = the angle of elevation/incline.

- A. Determine the coefficient of sliding friction on a horizontal plane. (Figure 1 shows the material and set-up needed to complete this task.) Show all your calculations and explain your work.

- B. Use the value you calculated for the coefficient of friction in Part A to help determine the amount of force needed to slide the object up a ramp (made of the same material as the horizontal plane) with an angle of elevation of 25°.

*Permission to reprint requested.

MATHEMATICS RUBRIC

NAME _____ DATE _____

- Exceeds standard (must receive a 4 in each area)
- Meets standard (must receive all 3's or a combination of 3's and 4's)
- Approaches standard (must receive all 2's or any combination which may include a 3 or a 4)
- Begins standard (has no 3's or 4's but not all 1's)
- Absent (has all 1's and 0's)

	Mathematical Knowledge	Strategic Knowledge	Explanation
4	<ul style="list-style-type: none"> • Wrote the right answer. • Used math words correctly to show understanding of how math works. • Worked it out with no mistakes. • Used the right math words and labeled the answers. 	<ul style="list-style-type: none"> • Identified all the important parts of the problem, and knew how they went together. • Showed all the steps used to solve the problem. 	<ul style="list-style-type: none"> • Wrote what was done and why it was done. • If a drawing was used, all of it was explained in writing.
3	<ul style="list-style-type: none"> • Knew how to do the problem, but made small mistakes. 	<ul style="list-style-type: none"> • Identified most of the important parts of the problem. • Showed most of the steps used to solve the problem. 	<ul style="list-style-type: none"> • Wrote mostly about what was done. • Wrote a little about why it was done. • If a drawing was used most of it was explained in writing.
2	<ul style="list-style-type: none"> • Understood a little, but made a lot of big mistakes. 	<ul style="list-style-type: none"> • Identified some of the important parts of the problem. • Showed some of the steps used to solve the problem. 	<ul style="list-style-type: none"> • Wrote some about what was done or why it was done but not both. • If a drawing was used, some of it was explained in writing.
1	<ul style="list-style-type: none"> • Tried to do the problem, but didn't understand it. 	<ul style="list-style-type: none"> • Identified almost no important parts of the problem. • Showed almost none of the steps used to solve the problem. 	<ul style="list-style-type: none"> • Wrote or drew something that didn't go with the answer. • Wrote an answer that was not clear.
0	<ul style="list-style-type: none"> • No answer attempted. 	<ul style="list-style-type: none"> • No strategy shown. 	<ul style="list-style-type: none"> • No written explanation.
Score			