INCLINED PLANE

Name: …… Date: ……

School: …… Class: ……

INITIAL QUESTIONS

Answer the following questions:

I. What is an inclined plane?

II. Where we find an inclined plane?

III. What is the advantage of using an inclined plane?

IV. Draw an inclined plane and explain how it works.

QUESTIONS BEFORE THE EXPERIMENTS

1) A car is held motionless on a ramp (ramp) with the help of a rope strapped to a dynamometer. **The same car** hangs vertically from a dynamometer. ***In which of the two cases is the dynamometer indicator greater?*** Explain by detailing all the forces exerted on the car in both cases.

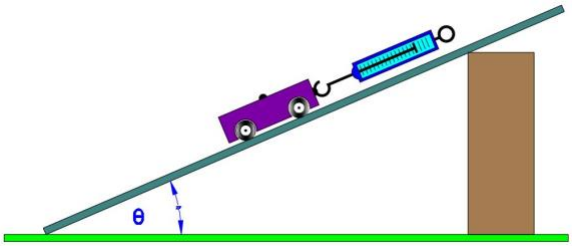


Figure 1

Figure 2

2) In the previous question, does the strength that the dynamometer count depends on the angle of the ramp? Yes or no? Explain.

3) If so, when the angle of inclination grows, what change do we expect to see in the dynamometer indicator?

4) When a body is still (has zero velocity) on a ramp, how much the net force on the parallel axis with the ramp is? Zero or various of zero?.....

5) Is it easier to pull an object upwards on a ramp or lift it vertically? Explain

6) Which parameter determines the size of the force required to pull an object up to a certain height using an inclined level? Explain.

7) Suppose that one body moves upwards on a ramp at a constant speed. How much do you think the net force is? Zero or various zero?

8) It's harder to lift an object than to decrease its height. Explain by using the concept of energy.

9) In order to lift an object to a specific height we will have to transfer energy to the body. This energy will be different if we raise the body vertically or through an inclined plane? If yes, in which case should we transfer more energy?

10) Let's suppose that we have two ramps with the same height but the second one has double length compared to the first. Which of the two ramps needs more energy to be raise the same object? Explain.

EXPERIMENTS

EQUIPMENT

Inclined plane with a vehicle, two dynamometers, protractor, rope and measuring tape.

EXPERIMENT 1

TITLE: FORCES ALONG AN INCLINED PLANE

FOR THE TEACHER

Students will:

analyze the weight in two axes and calculate the parallel and vertical force to the ramp.

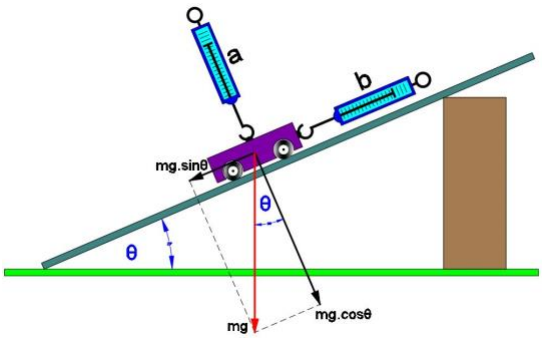
conclude that by using the inclined plane, they need less force in order to lift an object.

discover the relationship between the force needed and the angle of the inclined plane.

LAB SHEET

Procedure:

- ✓ Count the weight of the vehicle with a dynamometer w=mg =……



Picture 3

✓ Place the vehicle on the inclined plane with an angle of 15 degrees and connect it with the **dynamometers a and b** as presented in the picture 3. With the **dynamometer a** pull the vehicle so that the vehicle barely touches the inclined plane. When the body balances on the inclined plane take the indications of the dynamometers. The **dynamometer a** counts the normal force $\mathbf{F_N}$ and the **dynamometer b** counts the parallel force on the inclined F_X. Repeat the experiment on different angles that appear on board 1 and fill in the blanks.

BOARD 1

Ramp's angle in degrees (A)	**sinθ (B)**	**cosθ (C)**	**mgsinθ in N (D)**	**mgcosθ in N (E)**	**Parallel force F_x in N (F)**	**Normal force F_N in N (G)**
15	0,26	0.96				
30	0,50	0.87				
45	0,71	0.71				
60	0,87	0.50				
75	0,96	0.26				

11. Make a diagram from the values of board 1 in which the x axis will have the angle of inclination and in the y axis will have the parallel force on the inclined plane. What do you observe? Which is the relation between the angle of inclination and the indication of the dynamometer b?

12. Which will be the indication of the dynamometer b when the angle of inclination becomes 0 or 90 degrees?

13. Compare your results of the column (F) on board 1 with the weight of the vehicle. What do you observe?

14. Compare the results of columns (D) and (F) on board 1. What conclusion do you draw about the net force parallel to the inclined plane?

15. Compare the results of columns (E) and (G) on board 1. What conclusion do you draw about the net force vertically to the inclined plane?

16. Check your answers to the questions 1 to 4 according to board 1. Which are your conclusions?

Question 1

Question 2

Question 3

Question 4

17. Which one do you think is the main advantage of the use of the inclined plane?

EXPERIMENT 2

TITLE: MECHANICAL ADVANTAGES – WORK - ENERGY

FOR THE TEACHER

Students will conclude that when we lift an object in a specific height, the work needed is the same, either we lift it vertically or by using the inclined plane. This has to do with the gravitational potential energy.

Students will calculate the mechanical advantages in different angles.

In this way, they will acknowledge the advantages of using a simple machine in real life.

LAB SHEET

Definition of the mechanical advantages

The division of the weight (load) that we will lift to the force we act is called **actual mechanical advantage** of the inclined plane:

$$\text{A.M.A.} = \frac{\text{Weight(load)}we\ lift}{\text{Force}} = \frac{\text{mg}}{\text{F}\chi}$$

The division of the displacement of the acting force to the vertical displacement of the load is called **ideal mechanical advantage** of the inclined plane and depends on ramp's dimensions.

$$\text{I.M.A.} = \frac{\text{displacement}}{\text{vertical displacement of the load}} = \frac{S}{\text{h}}$$

Procedure

- ✓ Use the same vehicle. w=mg =…….
- ✓ Place the vehicle on the base of the inclined level with a 15 degrees angle and connect it with a dynamometer parallel to the inclined so that you drag the vehicle upwards with your hand. (figure 4) You have to lift the vehicle in height of h=0.40 m with constant velocity. The vehicle will move S meters on the inclined level. Slowly pull the vehicle so that the indication of the dynamometer will be stable. Repeat the experiment on different angles that appear on board 2 and fill in the gaps.

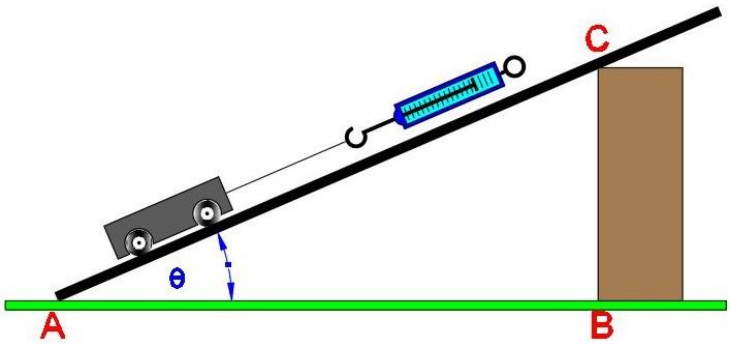


Figure 4

BOARD 2

Ramp's angle in degrees (A)	sinθ (B)	mg sinθ in N (C)	F_χ in N *(D)*	Displacement S in m (E)	F_χ* S in J (F)	A.M.A. mg/F_χ (G)	I.M.A. S/h (H)
15	0,26						
30	0,50						
45	0,71						
60	0,87						
75	0,96						

18. Draw in detail all the forces exerted on the vehicle in the case of experiment 2. Is there any difference between the design of forces in Experiments 1 and 2?

19. Compare the results of columns (C) and (D) of Board 2. What do you draw about the net force parallel to the ramp when the body moves at constant velocity?

20. Check your answers to the questions 5 to 7 according to board 2. Which are your conclusions?

    Question 5

    Question 6

    Question 7

21. In column F of board 2 you calculated the product between the input force and the vehicle's displacement. What happens to this product as the inclination angle of the inclined layer changes? What do you make of it?

22. Compare the ideal mechanical advantage (I.M.A.) and the actual mechanical advantage (A.M.A.). What do you observe? Explain.

23. When the inclination angle of the ramp is 30 degrees the s distance we move the vehicle on the ramp is ..... times the height we want to raise the body. Then the force we attract the vehicle is ..... times less than the weight of the vehicle.

24. By using an inclined plane we have a mechanical advantage. What does mechanical advantage mean? What do we gain and what do we lose?

25. You want to choose a ramp for your school so that it can climb at a steady speed α wheel chair with a traction force of 1/20 the weight of the wheel chair and rider. What should be the ratio of the height of the ramp to the length of the ramp? Explain.

Work and energy

Work of constant force

If an object undergoes a displacement S under the action of a constant force F, the work done is: **$W = F\,S\cos\theta$,** θ is the angle between the force and the displacement.
Work is a scalar quantity, and its unit is Joule (J). (1Joule=1N m).
Work is an energy transfer. If energy is transferred to the object, W is positive. If energy is transferred from the system, W is negative.

If vectors F and S have the same direction, $\theta = 0^o$ and $\cos\theta = 1$. Then: **W=F*S**
If vectors F and S have opposite directions, $\theta = 180^o$ and $\cos\theta = -1$. Then: **W=-F*S**
If vectors F and S have perpendicular the same direction, $\theta = 90^o$ and $\cos\theta = 01$. Then: **W=0**

Gravitational potential energy

To lift a body we need work. When we lift a body with weight mg to height h, we transfer to it energy equal to **mgh**. We call this product gravitational potential energy. Then:

U= mgh

Gravitational potential energy is a scalar quantity, and its unit is Joule (J). (1Joule=1N m).

✓ From board 2, calculate the work and the potential energy and fill the board 3.

BOARD 3

Ramp's angle in degrees (A)	Human's force work to lift the object by using inclined plane at height h=0.40 m $W=F_X*S$ in J (B)	Gravitational potential energy U=mgh at height h=0.40 m in J (C)
15		
30		
45		
60		
75		

✓ According the board 3 answer the following questions:

26. What do you notice about the work in different angles?

27. Compare the work of the human's force to the gravitational potential energy. What do you make of it?

28. From columns D, E and F of board 2 we observe that when the ramp's angle decreases, the indicator of the dynamometer ……., the displacement of the vehicle …… But the product remains …….. So when we gain in …… we lose in ……

29. Check your answers to the questions 8 to 10 according to board 3. Which are your conclusions?

Question 8

Question 9

Question 10

30. Explain why a road that goes up a mountain cannot go straight up and must have a lot of turns. What do we gain and lose by building roads in this way?