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Applying Concepts of Force and Torque to Different Parts of Human Body at Various Angles

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ABSTRACT:
The concepts of force and torque are very important topics in physics that have several significant applications in everyday life. For this research work, it was very interesting to test and confirm how the concept of force and torque can be applied to human body movements and small actions of daily life activities. In this experimental work, specifically, 12 parts of the body were considered, some of them have some addition weights on body part to see the effect of mass on movement of body. Various parts of human body were lifted at different angles while these experiments were performed to test effect of weight and angle of force and torque applied by parts of human body. This research work was performed as Honor Project of Physics I course and helped student to understand significance of concepts in her daily life activities.

KEYWORDS: *Physics, Force, Newton's Laws, Free Body Diagram, Vector and Component Method, Trigonometry, Torque, Human body, Math, Applications and Daily life activities.*

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I. INTRODUCTION

One of the aspects that makes physics one of the most fascinating and interesting subjects is that physics is in everything that surrounds us, from housework to work, everywhere. One of the most applied topics in real life is the concept of Force. **Force** is an interaction or alteration that causes the movement of an object to change and can also be described as push or pull and is expressed in Newtons (N) thanks to one of the greatest physicists in history, Isaac Newton. Thanks to his studies, he developed three laws.

The three laws of Newton are very important laws of Force that exist in this world everywhere. In short the *first* states that if an object is in a state of rest or in a state of motion at a constant speed along a straight line it continues in this state unless compelled to change that state by a net force. A net force in a vector sum of all of the forces acting on an object. This is also known as the law of inertia. Newton's *second* law relates mass and acceleration. In fact, when an external force acts on an object with a certain mass, the acceleration is directly proportional to the net force and the magnitude inversely proportional to the mass. A tool that helps us in the representation of the forces acting on an object is FBD, *Free Body Diagram*. This tool consists in graphically representing all the forces acting on the object, therefore the object can be represented with a square or a dot drawn on the intersection between the two x and y axes, and according to the type of force acting on it and depending on the amount of force, arrows are fired from the center of this square or dot. For example, the car shuts down due to a breakdown, so the two people inside are forced to move the car a little further to a rest area. The younger one applies a force of 275 N, the other instead of 395 N and there is an opposing force which is 560N, the representation with the FBD is as followed in Figure 1**[1]**:

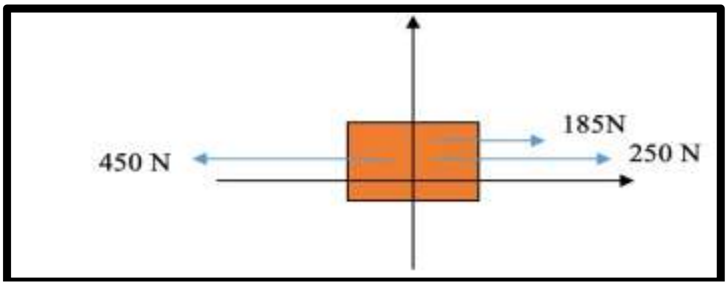


Figure 1: Representation of the example [2]

The*Newton's third law* states that when one object applies a force on a second object, the second object exerts an equal and opposite force on the first object. For example, we are sitting in a chair, the chair exerts an equal and opposite force on us. As it has been possible to notice so far, another topic that occurs very often in physics are vectors. *Vectors* are usually represented by arrows and give information about direction and magnitude. If they possess both characteristics, they are called vector quantity; if, on the other hand, they only have magnitude, they are scalar quantity. A very useful tool used in physics that involves the use of vectors is called the component method.The component method of vector addition is the standard way to add vectors and can be seen in Figure 2. $\mathbf{A} = \mathbf{A}_x x + \mathbf{A}_y y$. **[1]**

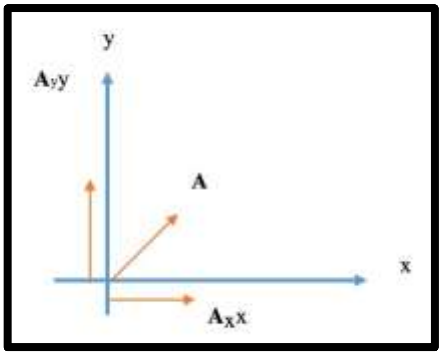


Figure 2:component method representation**[2]**

Physics cannot be used without mathematics and specifically Algebra and *trigonometry*. Trigonometry is the branch of mathematics dealing with the relations of the sides and angles of triangles and with the relevant functions of any angles. It is also very useful in physics. In this experience I have used many concepts contained in trigonometry such as, for example, how to find the sine of the angle having the opposite side and hypotenuse, in fact it is enough to divide the height by hypotenuse. Obtaining the sine of theta, it is possible to calculate the angle and find it by doing the inverse sine of theta. Trigonometry is used to find out angles the values of forces and torques in this research paper. **[1]**

The another most important concept of Physics that can be seen everywhere in the world from daily life to worldy applications is **Torque**. The Torque is the force that can twist an object and needed to rotate any object. Everywhere in the work if any object has a fixed end with ability to rotate and another end is free to rotate, it follows Torque. The Figure 3 shown below is an example of lifting a leg that shows how concepts of Force and Torque both are applied at the same time.

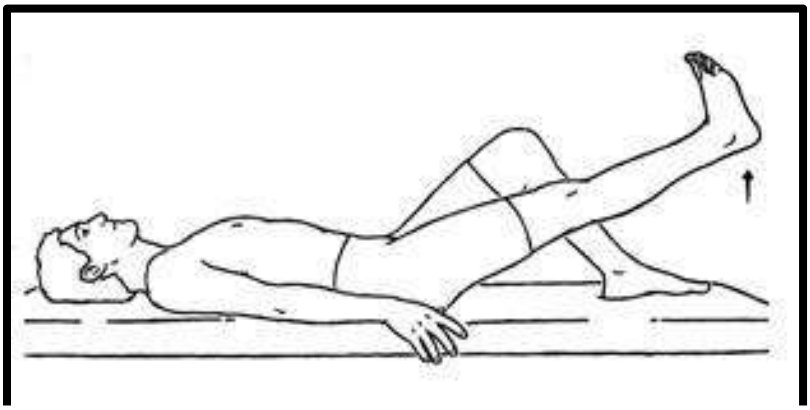


Figure 3: leg up. **[3]**

I have always found it very fascinating and interesting to understand how actions or facts of daily life can be explained from a scientific point of view. For this reason, I decided to deal with these topics, because they have a big application in everyday life. My experiment includes only a fraction of the concepts of physics that can be applied in everyday life but are of great importance. For example, in a hospital setting, knowing the angle at which the leg should be bent when it is broken is important in order to ensure correct circulation to the limb. Or in the gym, in order to perform exercises correctly while avoiding strains or other injuries, it is important to do the push-ups at a certain angle. **[1]**

II. MATERIAL AND THEORY USED

In this research work, following materials are used to perform hands on activities at home to collect data and complete this experimental work. String or meter, Ruler, Heavy box (10 kg), Bottle of water (500 g each), Measuring tape, Meter stick, Body part (half arm, full arm, full leg, half leg, total body, half body, finger, hand), Scotch tape, laptop, wifi, Microsoft Word.

For this experimental work, following theories and concepts of Physics I are used. These concepts are shown below in the form of equations of trigonometry, force, torque and component method. An example of an inclined plane with force acting on it can be seen in the Figure 4.

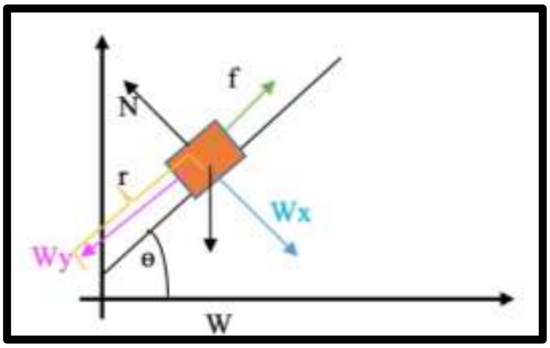


Figure 4: Representation inclined plane. [2]

Trigonometry

- Sinɵ = $\frac{\text{opposite}}{\text{Hypotenuse}}$ (1)

relates the opposite side to the hypotenuse.

- ɵ = Sin^1 (Sinɵ)

theta = inverse sin theta (2)

Forces/Weight

- W = m · g(3)

On inclined plane,

- W_x = m · g · Cosɵ (4)
- W_y =m·g· Sinɵ(5)
- N = W_x = m · g · Cosɵ(6)
- F = W_y =m·g· Sinɵ = Force applied to lift body part (7)

Torque

- τ = F*r or τ = F*r*Sinɵ' (8)
- ɵ' = 90 - ɵ (9)
- mass of a part of the body = $\frac{\text{\% of total body} \cdot \text{tot mass of the body}}{100}$ (10)

• Symbols •

ɵ = theta

τ = torque

m= mass of the body part

m_{tot} = total mass

m_{weight} = mass of the weight

g= accelaration due gravity

F_W = weight force

r= liver arm (distance from axis of rotatiton and center of gravity)

F = force

Height (h) = opposite

Hypotenuse (Hypo) = lenght of the body part

W = weight

III. PROJECT DETAILS

In this project, my goal is to see how equation of Force, Trigonometry and Torque and component method can be used for various part of the body and show how much Torque is applied. Is it also possible to notice how angle can change the amount of force applied when a body part is lifted at different inclination. I also want to show how physics is involved in everything we do. For example, if we want to change a refrigerator to be able to replace it with a new one, we need to tilt it at a certain angle on the trolley to be able to move it more easily.

For this project I picked 12 different body parts with and without adding weight and I moved those body part at 5 different inclinations creating 5 different angles. Through this, is possible understand how some concepts like, force vectors, Torque are acting at different angles, and also I want to see and understand where I feel most tired and what is the reason and the condition, for example, if I put my arm or another part of my body, at an a certain angle from the ground, at what angle I feel most tired and what will change if I add some weight at the part of my body.

What I did practically was using different part of the body such as half arm, leg, hand, etc at different angle to see how I feel, for example if I feel tired or relaxed and then how I can relate to the theories that I mentioned in the theory section. The details of each body part movement with its inclination angles can be seen in the results section.

IV. METHODS

In order to carry out this project, I followed some steps that are common to all 12 trials. Each trial considers a body part, and in some trials the same body part carries additional weight. Each trial with 5 cases, i.e. that part of the body under consideration was tilted at 5 different angles. First, I chose which parts of the body to consider that could form angles, and what I chose were: half arm, full arm, full leg, half leg, total body, half body, finger, hand. As I said, some of these will also have an additional weight in order to understand the differences that occur with and without weight. After doing this, I measured its length and reported the value of each body part in the respective table. Each body part has a personal chart, and in cases where that additional weight, there will be a chart for that case as well. After measuring the length of that body part, I started bending the body part at 5 different angles, starting from the zero one, i.e., from a rest situation, and increasing each time. I entered each angle I chose in the table, and calculated its sine, considering the length of the body part as the hypotenuse and the side opposite the angle as the height. After that, I found ɵ and ɵ', and with ɵ' I was able to find τ. Is possible see all the equations and formula used in the Theory section, and the results the in the following tables as shown in the result section.

V. RESULTS AND DATA ANALYSIS

The detailed data collection of all parts of bodies at various angles can be seen in this section where each table belong to each different parts of body movement. The figures shown next to each table shows how that body part was lifted to apply concepts of Force and Torque. All these body part movement can be seen in the Figures from Figure 5-13 and data details can be seen in the tables from Table 1-14. Sample of calculations can be seen in the calculation section of this paper.

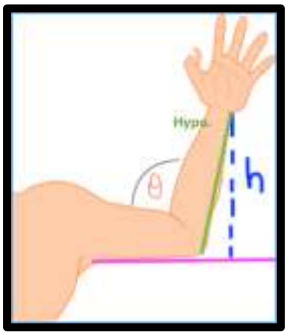


Table 1: HALF ARM
Hypotenuse = 42 cm → 0.42 m
m= 1.256 kg

Figure 5: half arm bent. [3]

CASE #	h (height in cm)	Sinɵ = $\frac{opp.}{Hypo.}$	ɵ = $Sin^1(\frac{opp.}{Hypo.})$	W_x = m • g • Cosɵ	W_y= m • g • Sinɵ
1	0 cm	$\frac{0}{42}$	0°	12.31 N	0 N
2	20 cm	$\frac{20}{42}$	28.03°	10.86 N	5.78 N
3	30 cm	$\frac{30}{42}$	45.58°	8.62N	8.79 N
4	40 cm	$\frac{40}{42}$	72.25°	3.75 N	11.72 N
5	42 cm	$\frac{42}{42}$	90°	0 N	12.03 N

Table 2: HALF ARM + WEIGHT (m_{tot}= m + m_{weight} = 1.256 kg + 0.500 kg = 1.756 kg)

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = Sin^{1} (Sinθ)	W_x = m • g • Cosθ	W_y = m • g • Sinθ
1	0 cm	$\frac{0}{42}$	0°	17.22 N	0 N
2	20 cm	$\frac{20}{42}$	28.03°	15.21 N	8.10 N
3	30 cm	$\frac{30}{42}$	45.58°	12.10 N	12.30 N
4	40 cm	$\frac{40}{42}$	72.25°	5.25 N	16.41 N
5	42 cm	$\frac{42}{42}$	90°	0 N	17.22 N

Table 3: FULL ARM
Hypotenuse = 74.5 cm→ 0.745 m
m= 3.9 kg

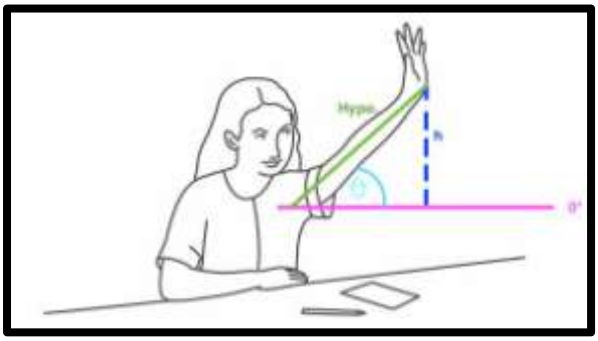


Figure 6: Full arm. [4]

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = Sin^{-1}($\frac{opp.}{Hypo.}$)	W_x = m • g • Cosθ	W_y = m • g • Sinθ
1	0 cm	$\frac{0}{74.5}$	0°	38.22 N	0 N
2	10.5 cm	$\frac{10.5}{74.5}$	8.10°	37.84 N	5.39 N
3	40 cm	$\frac{40}{74.5}$	32.5°	32.23 N	20.54 N
4	58.5 cm	$\frac{58.5}{74.5}$	51.7°	23.69 N	29.99N
5	74.5 cm	$\frac{74.5}{74.5}$	90°	30.03 N	38.22 N

Table 4: FULL ARM + WEIGHT (m_{tot}= m + m_{weight} = 3.9 kg + 0.500 kg = 4.48 kg)

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = Sin^{-1} ($\frac{opp.}{Hypo.}$)	W_X = m • g • Cosθ	W_Y = m • g • Sinθ
1	0 cm	$\frac{0}{74.5}$	0°	43.90 N	0 N
2	10.5 cm	$\frac{10.5}{74.5}$	8.10°	43.46 N	6.18 N
3	40 cm	$\frac{40}{74.5}$	32.5°	37.03 N	23.59 N
4	58.5 cm	$\frac{58.5}{74.5}$	51.7°	27.21 N	34.45 N
5	74.5 cm.	$\frac{74.5}{74.5}$	90°	0 N	43.90 N

Table 5: FINGER
Hypotenuse = 8.5 cm → 0.085 m
m= 22.95g → 0.02295 kg

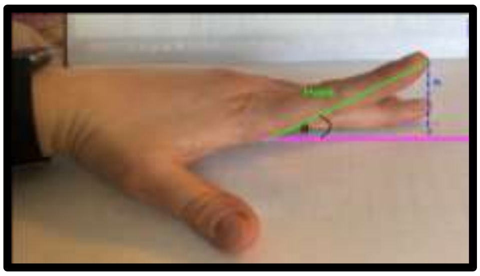


Figure 7: Finger making an angle. [2]

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = $Sin^{-1}(\frac{opp.}{Hypo.})$	$W_X = m \cdot g \cdot Cos\theta$	$W_Y = m \cdot g \cdot Sin\theta$
1	0 cm	$\frac{0}{8.5}$	0°	0.225 N	0 N
2	1 cm	$\frac{1}{8.5}$	6.76°	0.223 N	0.0265 N
3	3 cm	$\frac{3}{8.5}$	20.67°	0.210 N	0.0794 N
4	5 cm	$\frac{5}{8.5}$	36.03°	0.182 N	0.132 N
5	7 cm	$\frac{7}{8.5}$	55.44°	0.128 N	0.185 N

Table 6: HAND
Hypotenuse = 18 cm → 0.18 m
m= 0.4 kg

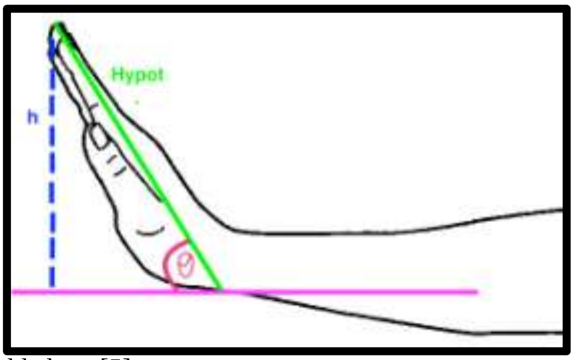


Figure 8: hand folded up. [5]

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = $Sin^{-1}(\frac{opp.}{Hypo.})$	$W_x = m \cdot g \cdot Cos\theta$	$W_y = m \cdot g \cdot Sin\theta$
1	0 cm	$\frac{0}{18}$	0°	3.92 N	0 N
2	7 cm	$\frac{7}{18}$	22.90°	3.61 N	1.53 N
3	12 cm	$\frac{12}{18}$	41.81°	2.92 N	2.61 N
4	15 cm	$\frac{15}{18}$	56.44°	2.17 N	3.27 N
5	18 cm (max height i could reach)	$\frac{18}{18}$	90°	0 N	3.92 N

Table 7: HALF BODY
Hypotenuse = 70.7 cm → 0.707 m
m= 40 kg

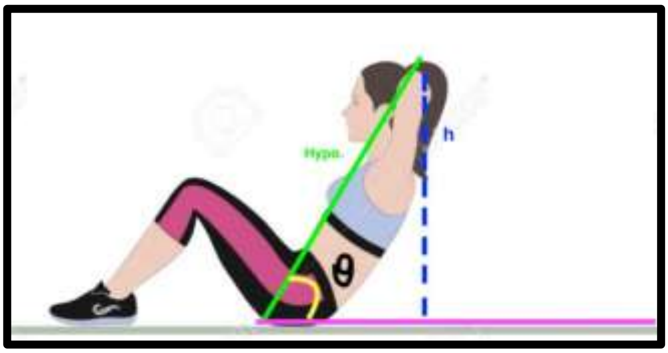


Figure 9: Do sit-ups creating angle. [6]

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = $Sin^{-1}(\frac{opp.}{Hypo.})$	$W_x = m \cdot g \cdot Cos\theta$	$W_y = m \cdot g \cdot Sin\theta$
1	0 cm	$\frac{0}{70.7}$	0°	392 N	0 N
2	25 cm	$\frac{25}{70.7}$	20.71°	366.67 N	138.63 N
3	50 cm	$\frac{50}{70.7}$	45.01°	277.14 N	277.23 N
4	60 cm	$\frac{60}{70.7}$	58.07°	207.32 N	332.69 N
5	70.7 cm	$\frac{70.7}{70.7}$	90°	0 N	392 N

Table 8: HALF BODY + WEIGHT (m_{tot}= m + m_{weight} = 40 kg + 10 kg = 50 kg)

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = $Sin^{-1}(\frac{opp.}{Hypo.})$	$W_x = m \cdot g \cdot Cos\theta$	$W_y = m \cdot g \cdot Sin\theta$
1	0 cm	$\frac{0}{70.7}$	0°	490 N	0 N
2	25 cm	$\frac{25}{70.7}$	20.71°	458.34 N	173.28 N
3	50 cm	$\frac{50}{70.7}$	45.01°	346.42 N	346.54 N
4	60 cm	$\frac{60}{70.7}$	58.07°	259.15 N	415.86 N
5	70.7 cm	$\frac{70.7}{70.7}$	90°	0 N	490 N

Table 9: FULL LEG
Hypotenuse: 89 cm → 0.89 m
m= 14.74 kg

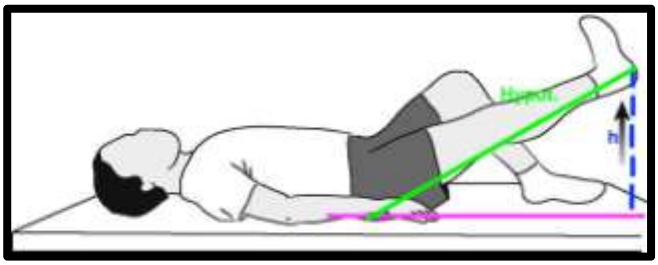


Figure 10: Lift the leg up.[7]

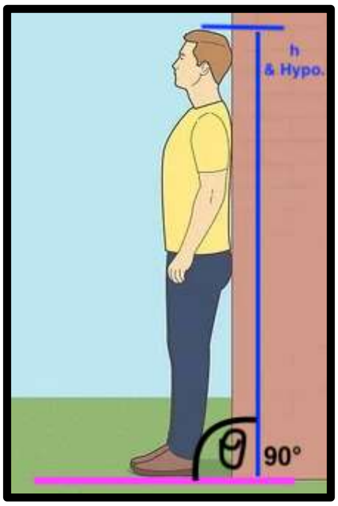
CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = $Sin^{-1}(\frac{opp.}{Hypo.})$	$W_x = m \cdot g \cdot Cos\theta$	$W_y = m \cdot g \cdot Sin\theta$
1	0 cm	$\frac{0}{89}$	0°	144.64 N	0 N
2	20 cm	$\frac{20}{89}$	12.99°	140.94 N	32.51 N
3	62 cm	$\frac{62}{89}$	44.16°	103.76 N	100.76 N

4	80 cm	$\frac{80}{89}$	64.01°	63.38 N	130.01 N
5	89 cm	$\frac{89}{89}$	90°	0 N	144.64 N

Table 10: FULL LEG + WEIGHT (m_{tot}= m + m_{weight} = 14.74 kg + 0.500 kg = 15.24 kg)

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = $Sin^{-1}(\frac{opp.}{Hypo.})$	W_x = m • g • Cosθ	W_y = m • g • Sinθ
1	0 cm	$\frac{0}{89}$	0°	149.54 N	0 N
2	20 cm	$\frac{20}{89}$	12.99°	145.72 N	33.61 N
3	62 cm	$\frac{62}{89}$	44.16°	107.28 N	104.18 N
4	80 cm	$\frac{80}{89}$	64.01°	65.53 N	134.42 N
5	89 cm	$\frac{89}{89}$	90°	0 N	149.54 N

Table 11: FULL BODY
Hypotenuse = 166 cm → 1.66m
m = 80 kg



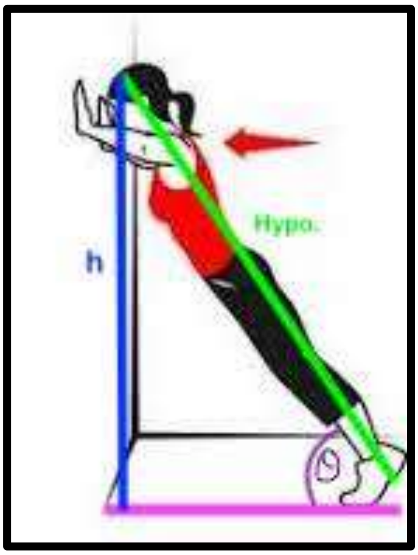


Figure 11: Person standing up. [8] **Figure 12:** wall push-ups.[9]

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = $Sin^{-1}(\frac{opp.}{Hypo.})$	W_x = m • g • Cosθ	W_y = m • g • Sinθ
1	98 cm	$\frac{98}{166}$	36.18°	632 N	462.81 N
2	121 cm	$\frac{121}{166}$	46.80°	536.68 N	571.51 N
3	144 cm	$\frac{144}{166}$	60.17°	389.98 N	680.12 N
4	160 cm	$\frac{160}{166}$	74.55°	208.86 N	755.67 N
5	166 cm	$\frac{166}{166}$	90°	0 N	784 N

Table 12: HALF LEG (supine)
Hypotenuse: 48.5 cm → 0.485 m
m = 4.28 kg

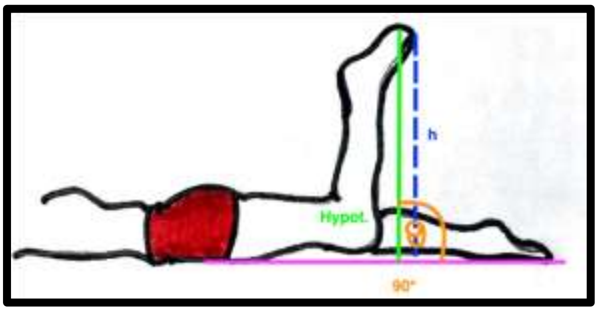


Figure 13: leg bent from prone position. [2]

CASE #	h (height in cm)	Sinθ = $\frac{opp.}{Hypo.}$	θ = $Sin^{-1}(\frac{opp.}{Hypo.})$	W_x = m • g • Cosθ	W_y = m • g • Sinθ
1	0 cm	$\frac{0}{48.5\ cm}$	0°	41.99 N	0 N
2	20 cm	$\frac{20}{48.5\ cm}$	24.35°	38.25 N	17.31 N
3	35 cm	$\frac{35}{48.5\ cm}$	46.19°	29.07 N	30.30 N
4	42 cm	$\frac{42}{48.5\ cm}$	59.99 °	21 N	36.36 N
5	48.5	$\frac{48.5}{48.5\ cm}$	90°	0 N	41.99 N

Table 13: TORQUE TABLE

Cases #	Part of the body	θ	θ' (90 - θ)	τ = F·r·Sinθ' (N·m)
1	**Half arm** m=1.256 kg* F = 12.32 N r = 0.21 m g = 9.81	0° 28.03° 45.58° 72.25° 90°	90° 61.97° 44.42° 17.75° 0°	2.59 N·m 2.28 N·m 1.81 N·m 0.79 N·m 0 N·m
2	**Half arm** **+ weight** m= 1.756 kg F = 17.23 N r = 0.21 m g = 9.81m/s^2	0° 28.03° 45.58° 72.25° 90°	90° 61.97° 44.42° 17.75° 0°	3.62 N·m 3.19 N·m 2.53 N·m 1.10 N·m 0 N·m
3	**Full arm** m= 3.9 kg F = 38.259 N r = 0.3725 m g = 9.81m/s^2	0° 8.10° 32.5° 51.7° 90°	90° 81.9° 57.5° 38.3° 0°	14.25 N·m 14.11 N·m 12.02 N·m 8.83 N·m 0 N·m
4	**Full arm + weight** m = 4.48 kg F = 43.95 N r = 0.3725 m g = 9.81 m/s^2	0° 8.10° 32.5° 51.7° 90°	90° 81.9° 57.5° 38.3° 0°	16.37 N·m 16.21 N·m 13.81N·m 10.15 N·m 0 N·m
5	**Finger** m = 0.02295 kg F = 0.225 N r = 0.0425 m g = 9.81 m/s^2	0° 6.76° 20.67° 36.03° 55.44°	90° 83.24° 69.33° 53.97° 34.56°	9.56 x 10^{-3}N·m 9.5 x 10^{-3} N·m 8.95 x 10^{-3}N·m 7.73 x 10^{-3}N·m 5.42 x 10^{-3}N·m
6	**Hand** m = 0.4kg F = 3.924 N r = 0.09 m g = 9.81 m/s^2	0° 22.90° 41.81° 56.44° 90°	90° 67.1° 48.19° 33.56° 0°	0.353 N·m 0.325 N·m 0.263 N·m 0.195 N·m 0 N·m
7	**Half body** m = 40 kg F = 392.4 N r = 0.3535 m g = 9.81 m/s^2	0° 20.71° 45.01° 58.07° 90°	90° 69.29° 44.99° 31.93° 0°	138.71 N·m 129.75 N·m 98.07 N·m 73.36 N·m 0 N·m
8	**Half body + weight**	0°	90°	173.4 N·m

	m = 50 kg F = 490.5 N r = 0.3535 m g = 9.81 m/s^2	20.71° 45.01° 58.07° 90°	69.29° 44.99° 31.93° 0°	162.19 N·m 122.59 N·m 91.70 N·m 0 N·m
9	**Full leg** m = 14.7 kg F = 144.207 N r = 0.445 m g = 9.81 m/s^2	0° 12.99° 44.16° 64.01° 90°	90° 77.01° 45.84° 25.99° 0°	64.17 N·m 62.53 N·m 46.04 N·m 28.12 N·m 0 N·m
10	**Full leg + weight** m= 15.24 kg F = 149.504 N r = 0.445 m g = 9.81 m/s^2	0° 12.99° 44.16° 64.01° 90°	90° 77.01° 45.84° 25.99° 0°	66.53 N·m 64.83 N·m 47.73 N·m 29.15 N·m 0 N·m
11	**Full body** m = 80 kg F = 784.8 N r = 0.83 m g = 9.81 m/s^2	36.18° 46.80° 60.17° 74.55° 90°	53.82° 43.2° 29.83° 15.45° 0°	525.78 N·m 445.90 N·m 324.017 N·m 173.53 N·m 0°
12	**Half leg** m = 4.28 kg F = 41.99 N r = 0.2425 m g = 9.81 m/s^2	0° 24.35° 46.19° 59.99° 90°	90° 65.65° 43.81° 30.01° 0°	10.18 N·m 9.28 N·m 7.05 N·m 5.09 N·m 0 N·m

VI. CALCULATIONS

Example: Half arm

- Half of arm s 1.57% of the total body mass, so using the formula mass of a part of the body = $\frac{\%\,of\ total\ body\ \cdot total\ mass\ of\ the\ body}{100}$, che massof half of my armi is: **1.256 kg.**
- To find the angle, I considered the lenght of my arm the hypotenuse, that is: **42 cm.**
- The height changes every time, but for the example i took just one: **20 cm**.

Sinɵ = $\frac{20}{42}$; ɵ = Sin^1 = 28.03°

W = 1.256 kg · 9.81 m/s^2 · Sin(28.03°) = 5.78 N (force experienced by the part of the body and reason why we feel tired when we move a part of the body with a certain angle).

W = 1.256 kg · 9.81 m/s^2 · Cos(28.03°) = 10.86 N (weight experienced by the body)

ɵ' = 90 - ɵ = 90 – 28.03 = 61.97 °

τ = F · r = F · r ·Sinɵ' = 12.32 N · 0.21 m · Sin61.97° = 2.59 N·m

VII. DISCUSSION

Thanks to this project that made me to understand that how many physics concepts are applicable in daily life, for example through the movements of parts of our body with or without weight. For example, when we bend our arm to drink or perform any other activity, our arm bends at a certain angle, and through concepts of physics and mathematics it is possible to calculate that angle, not only is it possible to calculate knowing the mass of the glass and the arm, how much weight force is felt by the arm. This is why by bending the arm at different angles we more or less feel the weight force acting. If the arm is fully extended on the table, we do not make any effort and therefore we do not feel tired in the arm. This is because it is in equilibrium, and the net force is balanced.

So working in this Honor Project this semester Fall 2022 in PHY-201 course made me able to show some physics concepts those are easily applicable in daily life and more specifically, how I applied concepts of Physics I on my different parts of body moving those parts at different angles. When I apply force at a certain angle, is possible to see that X and Y component of the weight are coming from this table, where x is balancing the normal force, instead y gives the effort that I applied to lift the body part. It is also possible to notice that **ɵ'** is the angle of my body part from vertical direction that's why to calculate it, is 90 - ɵ. It's also important to know that this concept is used by Torque, angle between how much force is applied to balance it from the distance of the axis of rotation, which is ɵ'. Also, when you look at the Torque, the force applied that is bringing Torque should have 90° relationship with liver arm, that's why we are looking for the angle from vertical and not horizontal for the Torque. Some significant results can be seen in the following summary Table 14 that shows one case for each part of the body around 45° angle.

Table 14: Summary Table

#	Body part	ɵ	Wy	Wx	ɵ'	τ
1	Half arm	45.58°	8.79 N	8.62 N	44.42°	1.81 N· m
2	Half arm + weight	45.58°	12.30 N	12.10 N	44.42°	2.53 N· m
3	Full arm	51.7°	29.99 N	23.69 N	38.3°	8.83 N· m
4	Full arm + weight	51.7°	34.45 N	27.21 N	38.3°	10.15 N· m
5	Finger	36.03°	0.132 N	0.182 N	53.97°	7.73 x $^{10-3}$N· m
6	Hand	41.81°	2.61 N	2.92 N	48.19°	0.263 N· m
7	Half body	45.01°	277.23 N	277.14 N	44.99°	98.07 N· m
8	Half body + weight	45.01°	346.54 N	346.42 N	44.99°	122.59 N· m
9	Full leg	44.16°	100.76 N	103.76 N	45.84°	46.04 N· m
10	Full leg + weight	44.16°	104.18 N	107.28 N	45.84 °	47.73 N· m
11	Full body	46.80°	755.67 N	208.86 N	43.2°	445.90 N· m
12	Half leg	46.19°	30.30 N	29.07 N	43.81°	7.05 N· m

VIII. CONCLUSION

This Honor Project has been a very interesting and useful experience, which has allowed me to verifyand to confirm that as the angle varies, the force and torque acting on that specific part of the body also varies. In fact, for example, if we consider the arm with or without additional weight, it is possible to notice that when the weight force is balanced by the net force or when it is at rest on the table, we do not feel particularly tired, while if we form an angle of 45 ° we feel more fatigue due to the weight force acting on the arm. It also possible see that as you change the angle, the weight can be divided into *x* and *y*, where *x*balances the normal force and the *y* component give the effort that I applied. In fact, noticing the tables, considering half arm, when is at rest (on the table), I didn't apply any force while my arm is on the table because the arm is balanced by the normal force. Furthermore, through this experience it is possible to understand how much the concepts of physics are applicable to everyday life.

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