Experiment #5: 
RWL from Psychophysical Data and NIOSH lifting equation.

Important definitions:
The NIOSH Lifting Equation is a tool used by occupational health and safety professionals to assess the manual material handling risks of low-back disorder associated with repeated lifting and lowering tasks in the workplace. This equation considers job task variables to determine safe lifting practices and guidelines. It consists of two primary products:

Recommended Weight Limit (RWL)
The weight of the load that nearly all healthy workers could perform over a substantial period of time without an increased risk of developing lifting-related low back pain.

Lifting Index (LI)
A term that provides a relative estimate of the level of physical stress associated with a particular manual lifting task.
LI = Weight of Load Lifted / RWL

Technical Requirements for Using the Revised NIOSH Equation
- Smooth Lift (no jerking)
- Two Handed Lift
- Moderate Width of Load (75 cm max)
- Unrestricted Posture
- Good Foot Traction
- Optimal Environment (Low humidity and temperature, good lighting, quiet).

RWL = LC x HM x VM x DM x AM x FM x CM

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Constant</td>
<td>LC</td>
<td>23 kg</td>
</tr>
<tr>
<td>Horizontal Multiplier</td>
<td>HM</td>
<td>(25/H)</td>
</tr>
<tr>
<td>Vertical Multiplier</td>
<td>VM</td>
<td>1-(.003</td>
</tr>
<tr>
<td>Distance Multiplier</td>
<td>DM</td>
<td>.82 + (4.5/D)</td>
</tr>
<tr>
<td>Asymmetric Multiplier</td>
<td>AM</td>
<td>1-(.0032A)</td>
</tr>
<tr>
<td>Frequency Multiplier</td>
<td>FM</td>
<td>From FM Table</td>
</tr>
<tr>
<td>Coupling Multiplier</td>
<td>CM</td>
<td>From CM Table</td>
</tr>
</tbody>
</table>
**Horizontal Location (H)** is the horizontal distance between the ankle mid-point and the point projected on the floor directly below the mid-point between the hand grasps.

\[ H = \frac{H_{\text{right hand}} + H_{\text{left hand}}}{2} \]

\[ 25 \leq H \leq 63 \text{ cm} \]

\[ 0.4 \leq HM \leq 1.0 \]

**Vertical Location (V)** is the vertical distance between the midpoint of the hands and the floor.

\[ V = \frac{V_{\text{right hand}} + V_{\text{left hand}}}{2} \]

\[ 0 \leq V \leq 175 \text{ cm} \]

\[ 0.7 \leq VM \leq 1.0 \]

**Distance (D)** is the vertical distance the load travels between the origin and destination of the lift. It is calculated by taking the difference between the \( V \) at the origin and \( V \) at the destination.

\[ 25 \leq D \leq 175 \text{ cm} \]

\[ 0.85 \leq DM \leq 1.0 \]

**Asymmetry Angle (A)** is the angle (in degrees) between the sagittal line and the asymmetry line in the horizontal plane.

**Sagittal Line** - line perpendicular to the hips and intersecting mid-point between ankles in neutral body posture.

**Asymmetry Line** - line connecting mid-point between ankles and midpoint between hands grasps at origin or destination of lift.

**Neutral Body Posture** - body posture when hands are directly in front of the body with no twisting at the legs, torso, or shoulders.

\[ 0 \leq A \leq 135 \text{ degrees} \]

\[ 0.57 \leq DM \leq 1.0 \]

**Frequency Multiplier (FM)** this multiplier is defined by

(a) Frequency (\( F \) - lifts/min)

(b) Duration of lifting (1, 2 or 8hr)

(c) Vertical height (\( V \)) from floor (<75cm or >75cm)

\[ F = \text{Number of lifts/min} \]

Use frequency averaged over a 15-minute period.
If \( F \leq 0.2 \) lifts/min, then \( F = 0.2 \)

**Duration Category (Work Pattern)**
The duration category is defined to be either

- short duration (1 hour or less)
- moderate duration (more than 1 hour, but not more than 2 hours)
- **Long duration** (more than 2 hours, but not more than 8 hours) of continuous lifting.

The work pattern is defined by the ratio of work-time (WT) to recovery-time (RT).
WT - Period of continuous lifting
RT - Period of light work following a period of continuous lifting.

- 1 hour - RT > 1.0 x WT
- 2 hour - RT > 0.3 x WT
- 8 hour – Standard industrial rest allowances required

*In order to maximize the FM and RWL, the lowest duration category is needed.*

**Coupling Multiplier (CM)** Nature of the coupling between the hands and the object being lifted. Coupling will be classified as Good, Fair, or Poor.

- Good - Handles or cutouts of optimal design. Comfortable grip where hand can be easily wrapped around the object.
- Fair - Less than optimal handles or lift with fingers flexed 90 degrees.
- Poor - No handles and unable to flex fingers under load.

**CM is determined from a Table**

Important notes:
- Multipliers can be used to identify specific job-related problems.
- RWL can be used as a maximum weight limit or target weight limit for design.
- LI can be used to compare job designs.
- LI can be used to set ergonomic design priorities.

**Apparatus**

- Box of width 34 cm with good couplings.
- Different weights.

**Experiment procedure:**

- Floor to 80 cm
- Two handed
- Symmetrical lifting
- 4 lifts/min
- 8-hr shift

**Procedure:**

- Adjust the weight of the box by filling it with the load appropriate for each subject (student) and apply several lifts to it.

- Take the measurements of the horizontal H distance and the vertical distance V, at both the origin and the destination for each subject.

- Carry out the task for at least 5 minutes and adjust the weight on an acceptable level for the subject.
• The timing and frequency controlling should be done while lifting the loads by other subject.

Note: the box should be back to its original position after each lift by different subject (student).
• Once the subject converges to the acceptable load, weigh the box and record its weight.

**Scoring and requirements:**

The score is the weight of the boxes and the dimensions of the vertical and horizontal distances for each subject.

Using the recorded scores for each student find out the following:

• Calculate the Average acceptable weight and standard deviation for males and femals. Assume your data is normal and calculate 90, 75, 50, 25, and 10 percentiles.

(Alternative method to calculate percentile for non-normal data is to sort your data in descending order –largest to smallest-. If your group has 25 students in it, then the 90\(^{th}\) percentile would be the mid value between the second and third and 50\(^{th}\) percentile would be the mid value between the12 and the 13\(^{th}\) value, and so on.)

• Compare class data with published data for males and females.

• Calculate the NIOSH RWL and compare it with the lowest value for the males in your group (the value 99\(^{th}\) of the male group consider acceptable), and the published data.

• Compare the NIOSH RWL with the 25\(^{th}\) percentile value for the females in your group (the value 75\(^{th}\) of the female group consider acceptable), and the published data.