

Prince of Songkla University
The Faculty of Engineering

Midterm Examination Semester I

Academic Year: 2009

Date: July 26, 2009

Time: 13:30 -16:30

Subject: 225-456 Ergonomics

Room: R300

ทูลิตในการสอบ โทษขันต่ำคือ ปรืบทกในรายวิชานัน และพักการเรียน **1** ภาคการศึกษา

DIRECTIONS

1. Two pieces of A4 noted sheets (both sides), dictionary and calculator are allowed.
2. 6 questions are given on 10 pages, and should be done.
3. Total score is 100.
4. RULA and NIOSH worksheet are attached.
5. Please check all questions/ pages before start working.

Good Luck

Asst.Prof Angoon Sungkhapong



1. It is realized that application of the laws of physics and of engineering concepts to the human body requires knowledge of the basic structure and function of the musculoskeletal system. To support this statement, all data in figure 1-5 should be completed.

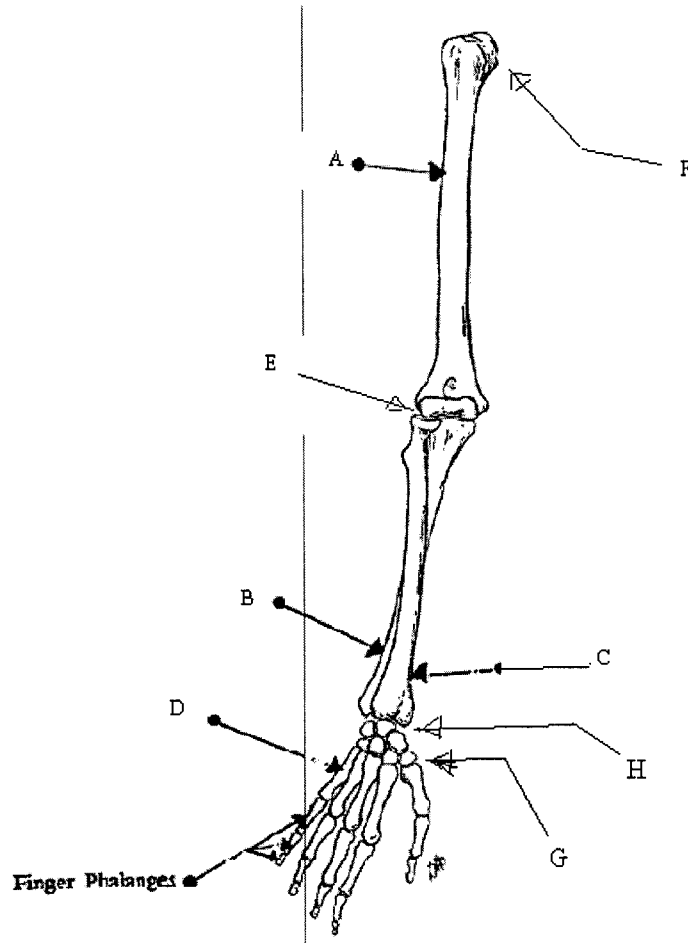


Figure 1: Upper limb bones

- 1.1 According to Figure 1, What are names of bones A, B, C, and D? (4 points)

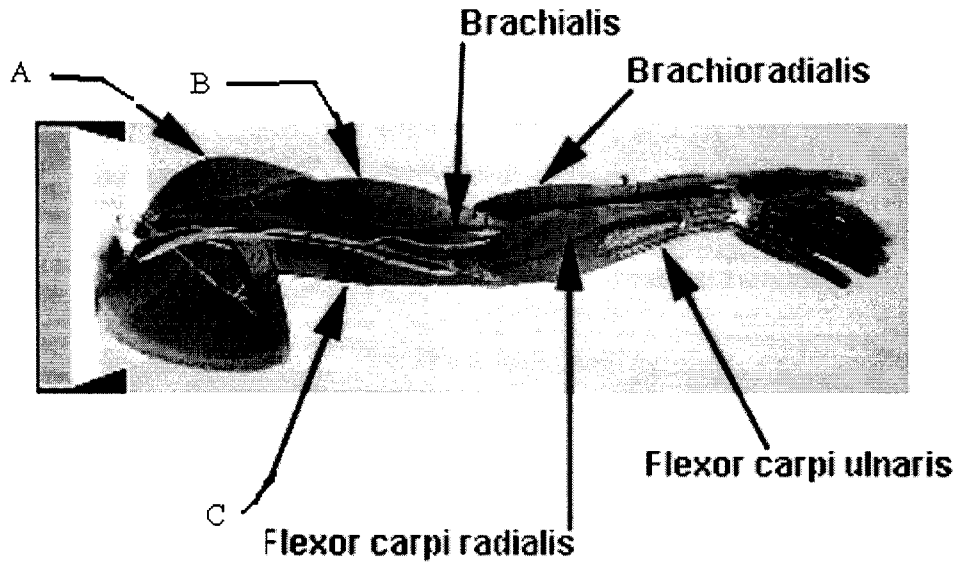


Figure 2 : Upper limb muscles

1.2 According to Figure 2, What are names of muscles A, B, and C? (3 points)

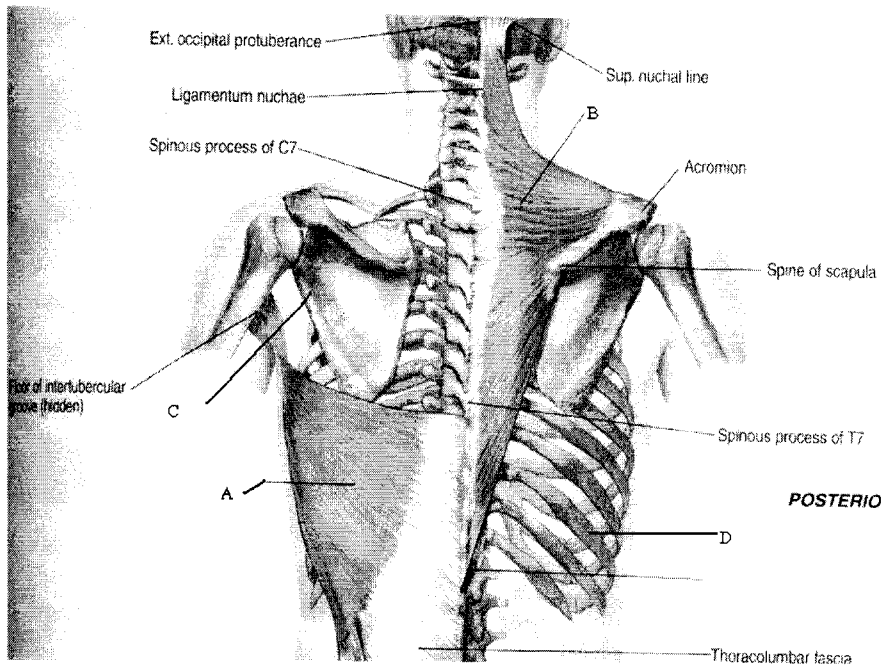


Figure 3: Muscles & bones of trunk

1.3. According to Figure 3, What are names of muscles A and B?
(2 points)

1.4. According to Figure 3, What are names of bones C and D?
(2 points)

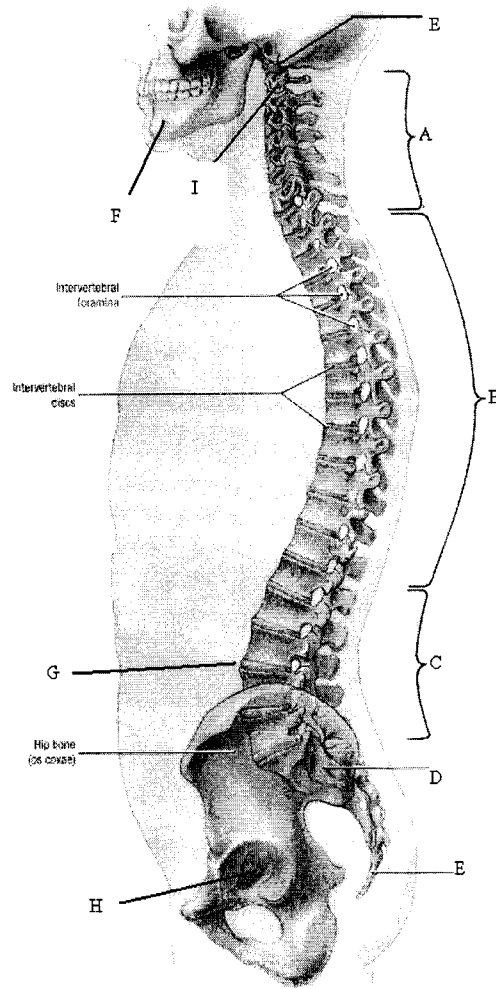


Figure 4: Spine

1.5. According to Figure 4, What are names of bones A, B, C, D, E and F? (6 points)

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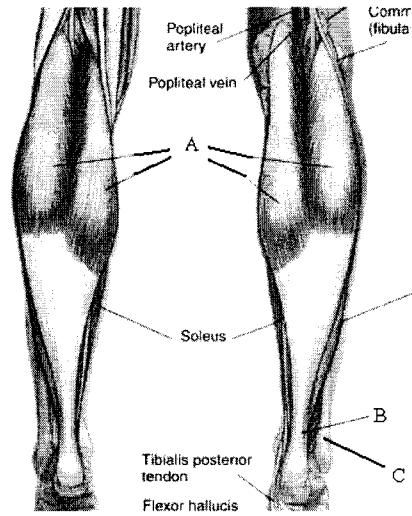


Figure 5 : Lower limb muscles

1.6. According to Figure 5, What are names of muscles A, tendon B and bone C? (3 points)

2. The human body could move in different plain because of the different joint in the skeletal system. Describe the information in question 2.1-2.4.

2.1. According to Figure 1, What kind of joint at location E, F, G and H? (4 points)

2.2. According to Figure 4, What kind of joint at location E, I, G and H? (4 points)

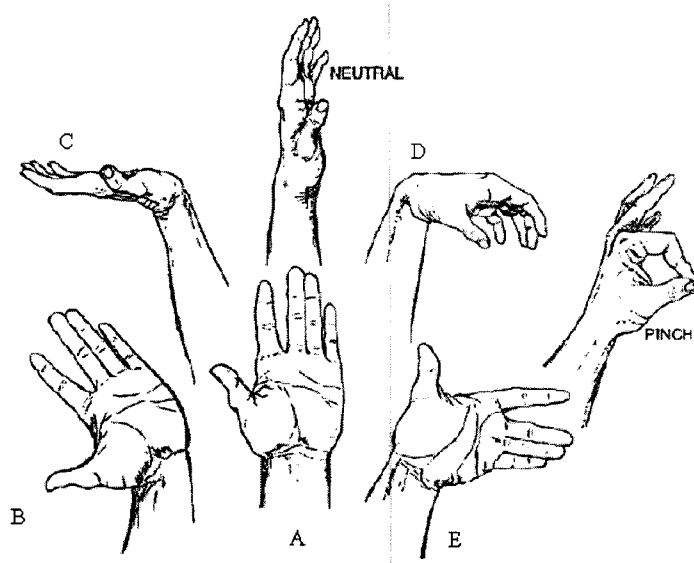


Figure 6: movement of hand

2.3. According to figure 6, describe the name of each movement and explain how does it affect to work- injury? (10 points)

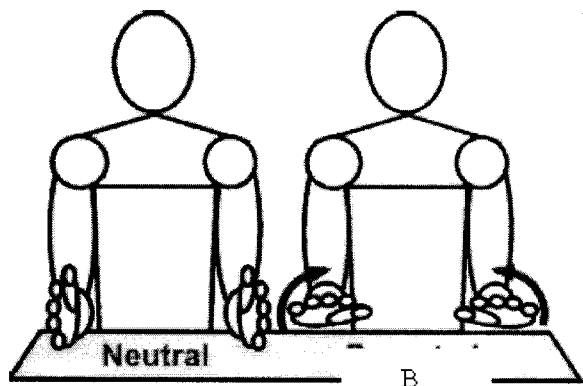


Figure 7: movement of forearm

2.4. What is movement of forearm as shown in figure 7(B)? (2 points)

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3. According to figure 8, Given data :- joint supports 300 Newton of body weight and the force-arm (B-C) is 12 cm., the abductor muscles (muscle force) are producing 'x' Newton of tension with the angle of 80 degree from horizontal line and the distance between A and B is 10 cm. How much compression acts on the hip during two-legged standing and what is it direction? What is the magnitude of 'x' ? (12 points) [B is the fulcrum at hip joint.]

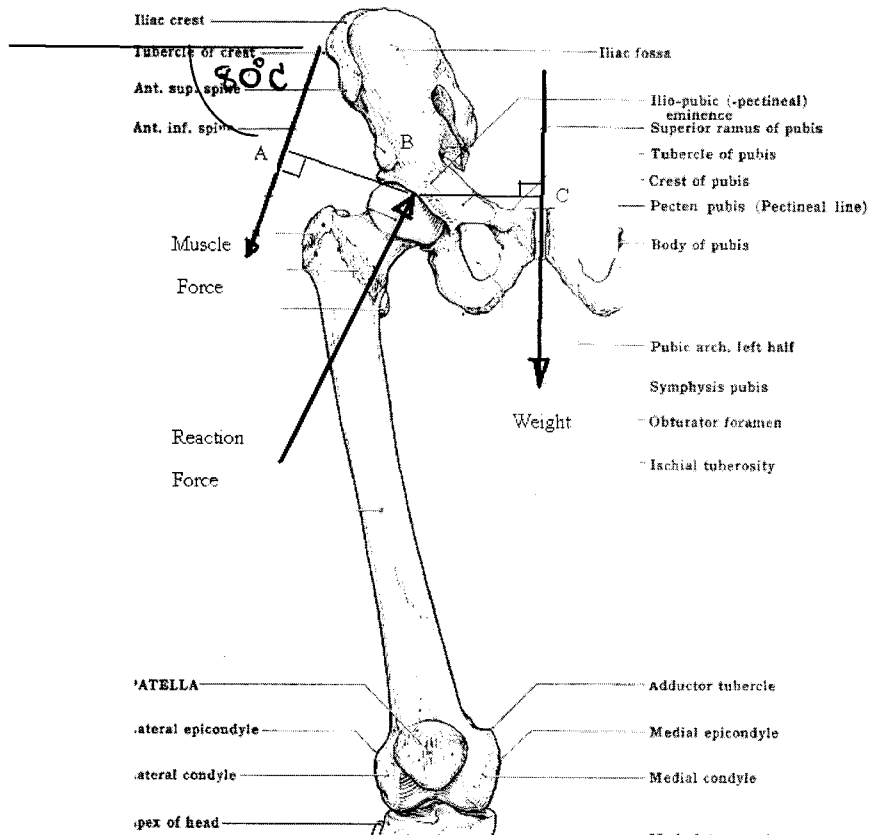


Figure 8: FBD of forces

4. The lower pulley, weighting 3.0 lb. with 8 lb. of patient's head, is supported by the strands of the pulley system. How much lift is applied to the patient if the therapist pulls on the rope with a force of 20 lb.? (8 points)

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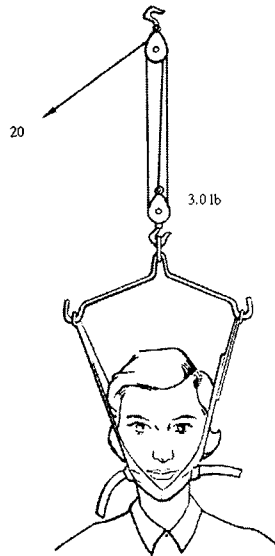


Figure 9: A patient with the pulley system

5. The operator is working as shown in figure 10-12 .Apply RULA to analyze the working position and propose the better working method. [Hint: improved work should be related to tools, working position, work station and working method]



Figure 10: The posture of worker while nailing the board.

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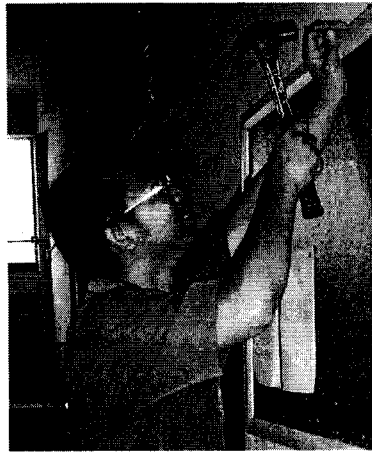
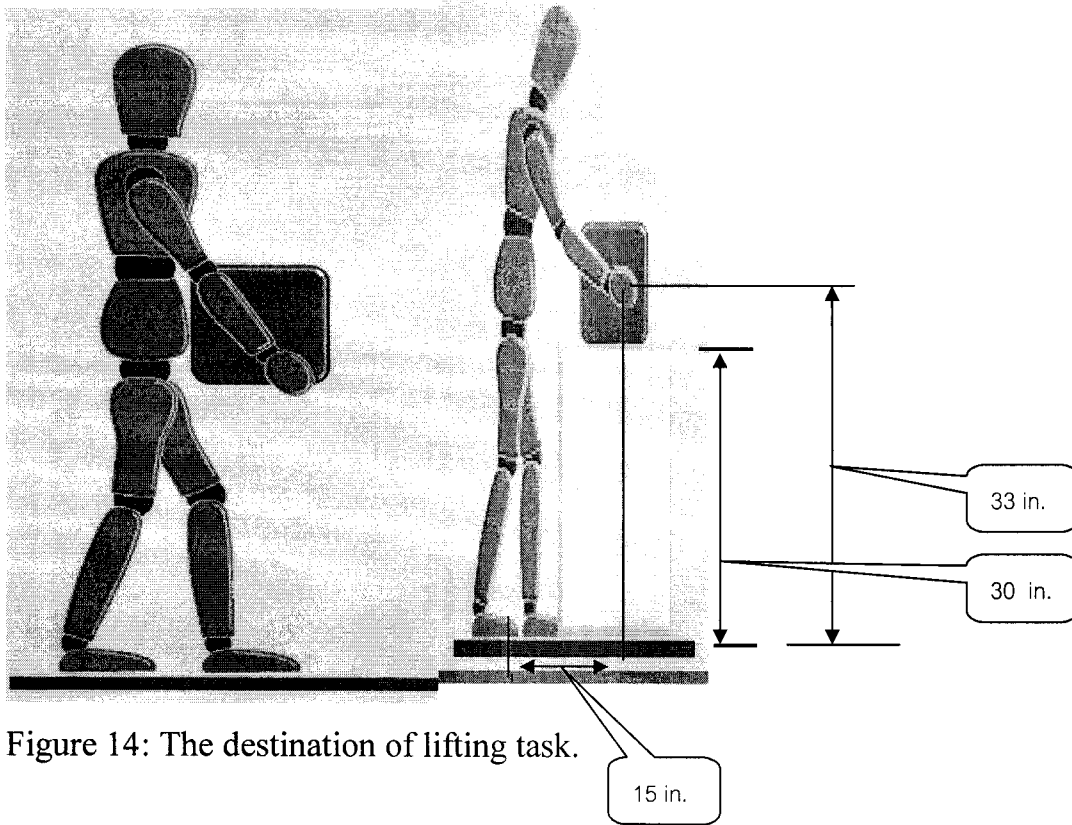
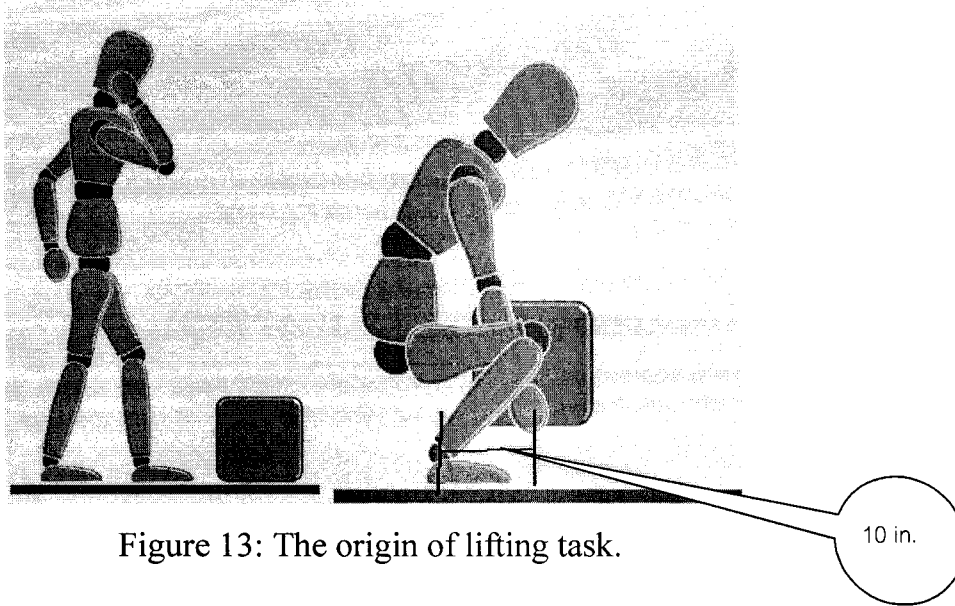


Figure 11: The upper limbs of worker while nailing the board.



Figure 12: The location of his hand while nailing the board.

6. Some cartons weighing 35 lbs are to be picked up from the floor (figure 13) and will be placed on a table 30" above floor level. The worker has to carry the carton and walk to the table about 1 ft. At the lowering position, hand holds are located 33" above the floor and 15" forward of the midpoint of the worker's ankles (figure 14). The average frequency of lifting is 4 lifts per hour and the task duration is 3 hours. The worker doesn't need to rotate his body while doing this task. Apply NIOSH to evaluate the job and propose the better working station or working method.



***** THE END *****

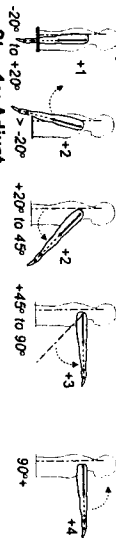
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RULA Employee Assessment Worksheet

Complete this worksheet following the step-by-step procedure below. Keep a copy in the employee's personnel folder for future reference.

A. Arm & Wrist Analysis

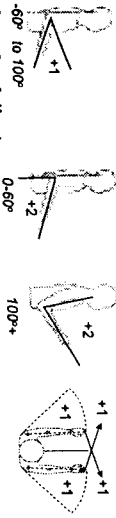
Step 1: Locate Upper Arm Position



If shoulder is raised: +1;
If upper arm is flexed: +1;
If arm is supported or person is leaning: -1

Final Upper Arm Score =

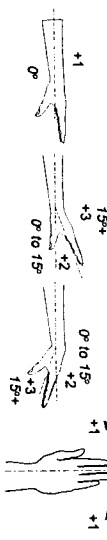
Step 2: Locate Lower Arm Position



Step 2a: Adjust...
If arm is working across midline of the body: +1;
If arm out to side of body: +1

Final Lower Arm Score =

Step 3: Locate Wrist Position



Step 3a: Adjust...
If wrist is bent from the midline: +1

Final Wrist Score =

Step 4: Wrist Twist

If wrist is twisted mainly in mid-range = 1;
If wrist at or near end of twisting range = 2

Wrist Twist Score =

Step 5: Look-up Posture Score in Table A

Use values from steps 1, 2, 3 & 4 to locate Posture Score in Table A

Posture Score A =

Step 6: Add Muscle Use Score

If posture mainly static (i.e. held for longer than 1 minute) or if action repeatedly occurs 4 times per minute or more: +1

Muscle Use Score =

Step 7: Add Foreload Score

If load less than 2 kg (intermittent): +0;
If 2 kg to 10 kg (intermittent): +1;
If 2 kg to 10 kg (static or repeated): +2;
If more than 10 kg load or repeated or shocks: +3

Foreload Score =

Step 8: Find Row in Table C

The completed score from the Arm/Wrist analysis is used to find the row on Table C

Final Wrist & Arm Score =

SCORES

Table A

Upper Arm	Lower Arm	Wrist							
		1	2	3	4				
1	1	1	2	2	2	3	3	3	3
2	2	2	2	2	3	3	3	3	3
3	2	2	3	3	3	3	3	3	3
4	2	2	3	3	3	3	3	3	3
1	1	2	2	2	2	3	3	3	3
2	2	2	2	2	2	3	3	3	3
3	2	2	2	2	2	3	3	3	3
4	2	2	2	2	2	3	3	3	3
1	1	2	2	2	2	3	3	3	3
2	2	2	2	2	2	3	3	3	3
3	2	2	2	2	2	3	3	3	3
4	2	2	2	2	2	3	3	3	3
1	1	2	2	2	2	3	3	3	3
2	2	2	2	2	2	3	3	3	3
3	2	2	2	2	2	3	3	3	3
4	2	2	2	2	2	3	3	3	3
1	1	2	2	2	2	3	3	3	3
2	2	2	2	2	2	3	3	3	3
3	2	2	2	2	2	3	3	3	3
4	2	2	2	2	2	3	3	3	3
1	1	2	2	2	2	3	3	3	3
2	2	2	2	2	2	3	3	3	3
3	2	2	2	2	2	3	3	3	3
4	2	2	2	2	2	3	3	3	3

Table B

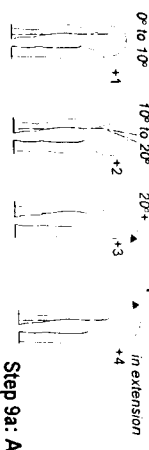
1	Trunk Posture Score					
	1	2	3	4	5	6
1	1	2	3	4	5	7+
2	2	2	3	3	4	5
3	3	3	3	4	4	5
4	3	3	3	4	4	5
5	4	4	4	5	5	6
6	4	4	4	5	5	6
7	5	5	5	6	6	7
8	5	5	5	6	6	7
9	5	5	5	6	6	7

Table C

Final Wrist & Arm Score	Final Score						
	1	2	3	4	5	6	7+
1	1	2	3	3	4	4	5
2	2	2	3	3	4	4	5
3	3	3	3	4	4	4	5
4	3	3	3	4	4	4	5
5	4	4	4	5	5	5	6
6	4	4	4	5	5	5	6
7	5	5	5	6	6	6	7
8	5	5	5	6	6	6	7
9	5	5	5	6	6	6	7

B. Neck, Trunk & Leg Analysis

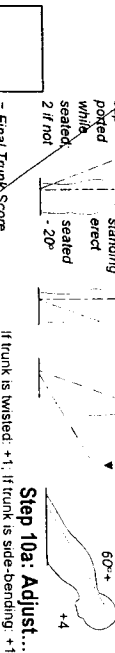
Step 9: Locate Neck Position



Step 9a: Adjust...
If neck is twisted: +1. If neck is side-bending: +1
If neck is flexed or person is leaning: -1

Final Neck Score =

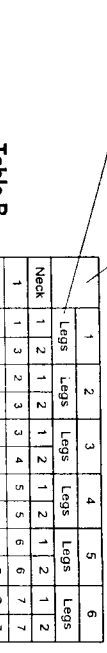
Step 10: Locate Trunk Position



Step 10a: Adjust...
If trunk is twisted: +1. If trunk is side-bending: +1
If legs & feet supported and balanced: +1
If not: +2

Final Trunk Score =

Step 11: Legs



Step 11a: Adjust...
If legs & feet supported and balanced: +1
If not: +2

Final Leg Score =

Table B

1	Trunk Posture Score					
	1	2	3	4	5	6
1	1	2	3	4	5	7+
2	2	2	3	3	4	5
3	3	3	3	4	4	5
4	3	3	3	4	4	5
5	4	4	4	5	5	6
6	4	4	4	5	5	6
7	5	5	5	6	6	7
8	5	5	5	6	6	7
9	5	5	5	6	6	7

Step 12: Look-up Posture Score in Table B

Use values from steps 8, 9, & 10 to locate Posture Score in Table B

Posture Score B =

Step 13: Add Muscle Use Score

If posture mainly static or if action 4/minute or more: +1

Muscle Use Score =

Step 14: Add Foreload Score

If load less than 2 kg (intermittent): +0;
If 2 kg to 10 kg (intermittent): +1;
If 2 kg to 10 kg (static or repeated): +2;
If more than 10 kg load or repeated or shocks: +3

Foreload Score =

Step 15: Find Column in Table C

The completed score from the Neck/Trunk & Leg analysis is used to find the column on Chart C

Final Neck, Trunk & Leg Score =

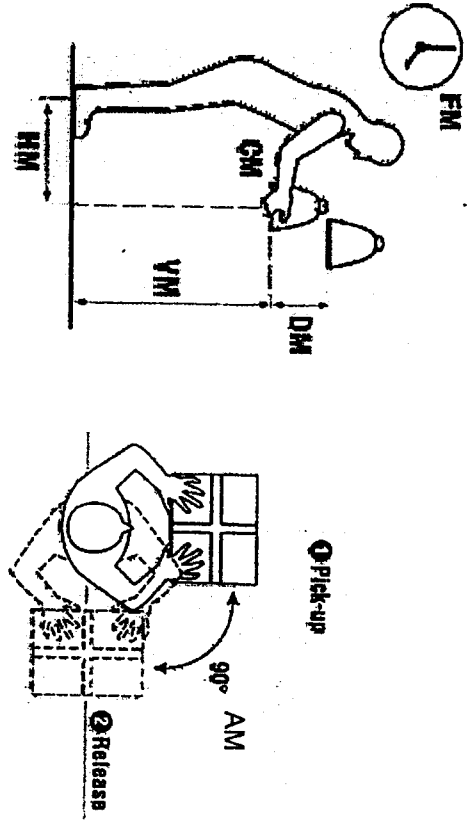
Subject: _____
Company: _____

Department: _____

Scorer: _____
Date: / /

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately

การวัดระยะทางโดยเส้นตรงจากสมการ NIOSH



NIOSH Lifting Equation 1991

$$VM = (1 - (0.003 * \text{abs}(V - 75)))$$

Table 2
Vertical Multiplier

$$VM = (1 - (0.0075 * \text{abs}(V - 30)))$$

V	VM	V	VM
in	cm	in	cm
0	.78	0	.78
5	.81	10	.81
10	.85	20	.84
15	.89	30	.87
20	.93	40	.90
25	.96	50	.93
30	1.00	60	.96
35	.96	70	.99
40	.93	80	.94
45	.89	90	.96
50	.85	100	.93
55	.81	110	.90
60	.78	120	.87
65	.74	130	.84
70	.70	140	.81
>70	.00	150	.78
		160	.75
		170	.72
		175	.70
		>175	.00

NIOSH Lifting Equation 1991

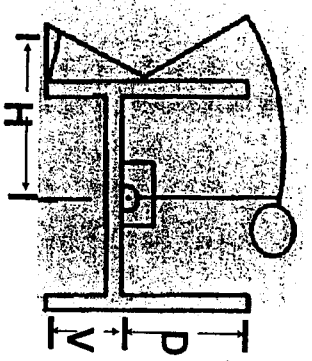


Table 1
Horizontal Multiplier

$$HM = 25/H$$

H	HM	H	HM
in	cm	in	cm
≤10	1.00	≤25	1.00
11	.91	28	.89
12	.83	30	.83
13	.77	32	.78
14	.71	34	.74
15	.67	36	.69
16	.63	38	.66
17	.59	40	.63
18	.56	42	.60
19	.53	44	.57
20	.50	46	.54
21	.48	48	.52
22	.46	50	.50
23	.44	52	.48
24	.42	54	.46
25	.40	56	.45
>25	.00	58	.43
		60	.42
		63	.40
		>63	.00

NIOSH Lifting Equation 1991

H [Horizontal Location]
ระยะแนวราบวัดจากจุดศูนย์กลาง
ข้อเท้าถึงจุดศูนย์กลางมือที่จับวัตถุ

Even less than 25 is considered as 25 cm

$$DM = (0.82 + (4.5/D))$$

$$DM = (0.82 + (1.8/D))$$

Table 3
Distance Multiplier

D	DM	D	DM
in	cm	in	cm
≤10	1.00	≤25	1.00
15	.94	40	.93
20	.91	55	.90
25	.89	70	.88
30	.88	85	.87
35	.87	100	.87
40	.87	115	.86
45	.86	130	.86
50	.86	145	.85
55	.85	160	.85
60	.85	175	.85
70	.85	>175	.00
>70	.00		

NIOSH Lifting Equation 1991

AM = (1-(0.0032A))

Table 4
Asymmetric Multiplier

A	AM
deg	1.00
0	1.00
15	.95
30	.90
45	.86
60	.81
75	.76
90	.71
105	.66
120	.62
135	.57
>135	.00

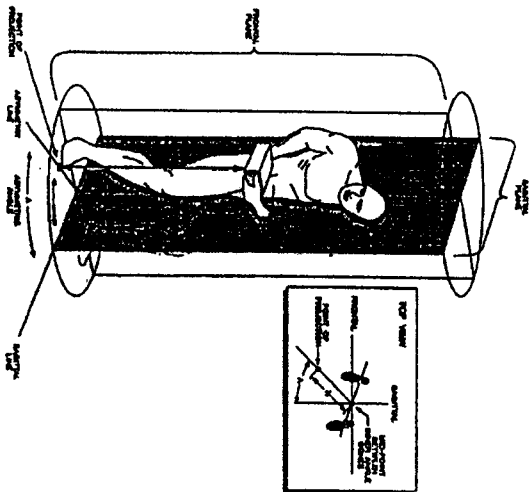


Figure 2 Graphic Representation of Angle of Asymmetry (A)

NIOSH Lifting Equation 1991

รูปแบบแสดงระนาบกลางลำตัวและการวัดมุมในการหมุนตัว

Coupling Factor [CM]

GOOD = 1.0 FAIR = 1.0 or .95 POOR = .90

1. วัตถุประสงค์ที่เหมาะสม
กรณีคือ

2. ของที่ยกไม่เหมาะสม
สามารถยึดได้

Coupling Type	Coupling Multiplier	
	V < 75 ซม.	V ≥ 75 ซม.
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

NIOSH Lifting Equation 1991

ตารางตัวคูณของปัจจัยความถี่ (FM) ขึ้นกับค่า F, D, V

ความถี่ จำนวนยกต่อ ชั่วโมง	ขนาดของน้ำหนักยก							
	น้ำหนัก 1 ส่วนสี่		น้ำหนัก 1 ถึง 2 ส่วนสี่		น้ำหนัก 2 ถึง 3 ส่วนสี่		น้ำหนัก 3 ถึง 4 ส่วนสี่	
	V < 75 ซม.	V ≥ 75 ซม.	V < 75 ซม.	V ≥ 75 ซม.	V < 75 ซม.	V ≥ 75 ซม.	V < 75 ซม.	V ≥ 75 ซม.
5.02	1.00	1.00	0.95	0.95	0.85	0.85		
0.5	0.97	0.97	0.92	0.92	0.81	0.81		
1	0.94	0.94	0.88	0.88	0.75	0.75		
2	0.91	0.91	0.84	0.84	0.65	0.65		
3	0.88	0.88	0.79	0.79	0.55	0.55		
4	0.84	0.84	0.72	0.72	0.45	0.45		
5	0.80	0.80	0.60	0.60	0.35	0.35		
6	0.75	0.75	0.50	0.50	0.27	0.27		
7	0.70	0.70	0.42	0.42	0.22	0.22		
8	0.60	0.60	0.35	0.35	0.18	0.18		
9	0.52	0.52	0.30	0.30	0.15	0.15		
10	0.45	0.45	0.26	0.26	0.13	0.13		
11	0.41	0.41	0.23	0.23	0.10	0.10		
12	0.37	0.37	0.21	0.21	0.08	0.08		
13	0.34	0.34	0.19	0.19	0.07	0.07		
14	0.31	0.31	0.17	0.17	0.06	0.06		
15	0.28	0.28	0.15	0.15	0.05	0.05		
> 15	0	0	0	0	0	0		

NIOSH Lifting Equation 1991

ตารางสูตรการ NIOSH 1991

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

	METRIC	U.S. CUSTOMARY
Load Constant	LC 23 kg	51 lb
Horizontal Multiplier	HM (25/H)	(10/H)
Vertical Multiplier	VM 1-(.003 V-75)	1-(.0075 V-30)
Distance Multiplier	DM .82 + (4.5/D)	.82 + (1.8/D)
Asymmetric Multiplier	AM 1-(.0032A)	1-(.0032A)
Frequency Multiplier	FM From Table 5	From Table 5
Coupling Multiplier	CM From Table 7	From Table 7

NIOSH Lifting Equation 1991