Prince of Songkla University
The Faculty of Engineering

Final Examination Semester I   **Academic Year: 2006**

Date: October 10, 06   **Time: 13:30 -16:30**

Subject: 226-443 Ergonomics   **Room: R201**

ทุจริตในการสอบ โทษขั้นต่ำคือ ปรับตกในรายวิชานั้น และพักการเรียน **1** ภาคการศึกษา

DIRECTIONS
1. Only short note on an A4 piece (both sides), dictionary and calculator are allowed.
2. Attend all questions (5 questions are given on page 1-8, important documents are shown on page 9-11).
3. Total score is 100.
4. Your answers could be in English or Thai.
5. Please check all questions before start working.

Good Luck

Asst.Prof.Dr. Angoon Sungkhapong

1. A worker is painting the office wall as shown in figure 1. The weight of his equipment is 1.2 kg and the frequency of moving his hands is 10 times per minute.

    1.1) Evaluate the working posture by using RULA method. (10 points)

    1.2) Propose the practical workstation and working method for health, safety and work improvement. (10 points)
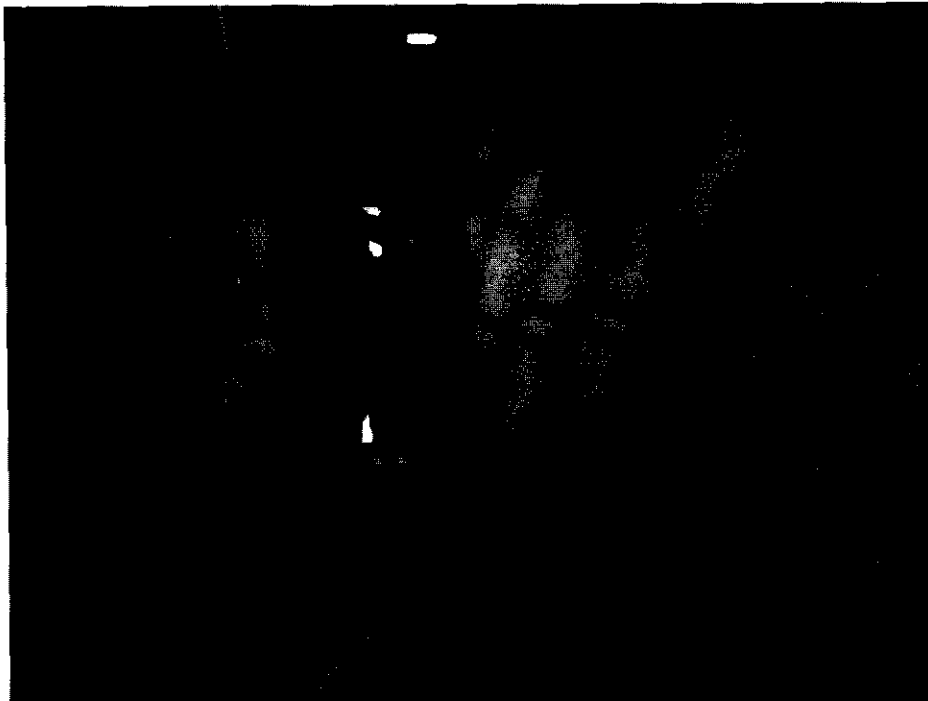

Figure 1: Show the posture of a worker (for question #1).

2. Compare five differences of the capacity and limitation of human and machine in working systems. (10 points)

3. A 124 lb lady is lifting her 33 lb baby who is standing on the floor to the upper bed (figure 2-3). The weight of some body segments and other important data are given in table 1. The center of mass, for all upper body part of the lady, is located I inches from L5/S1 joint as shown in figure 3.

    3.1) What kind of lever system occurred at L5/S1 joint ? (10 points)

3.2) Do analysis the working posture by using revised NIOSH lifting equation if the baby who is standing on the floor is lifted till her feet is 20 inches above the floor. (15 points)

3.3) Calculate the reaction force at the hip joint and the value of back muscle force while the lady is holding her baby. (10 points)
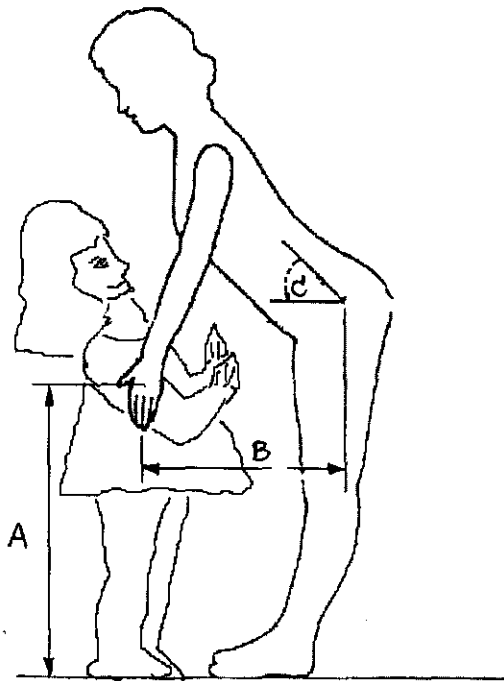

Figure 2: Show posture & all dimensions when a lady starts to lift her baby.
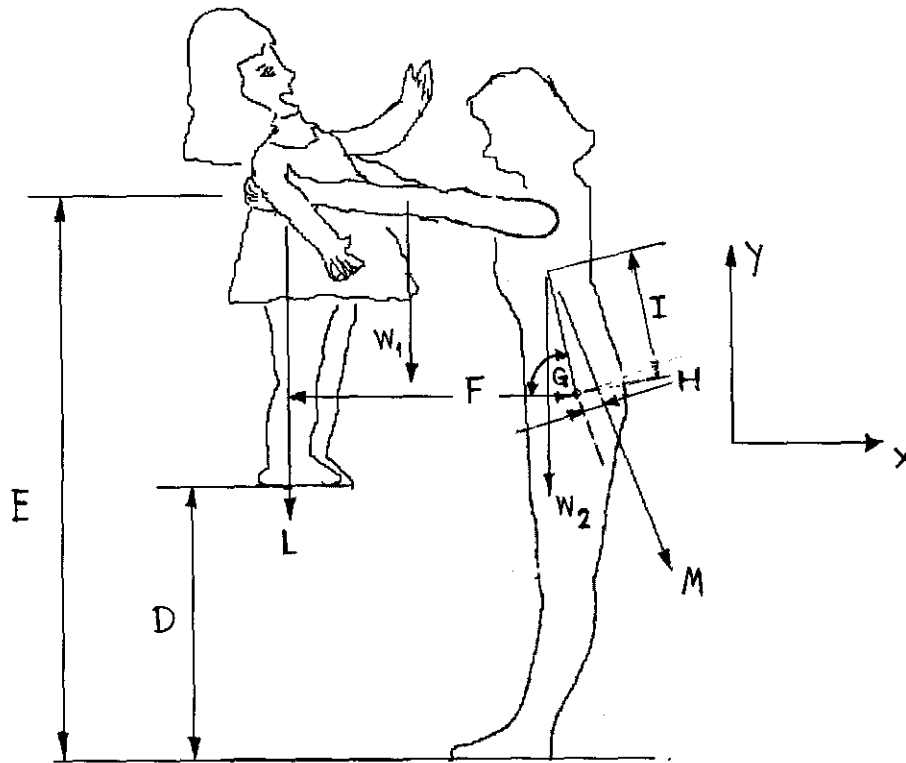
Figure 3: Show posture & all dimensions while a lady is lifting her baby.

Table 1: Important data for question #3.

Symbols/data	Value	unit
A	29.5	inch
B	14.2	inch
C	45	degree
D	20	inch
E	49.5	inch
F	20	inch
G	85	degree
H	1	inch
I	12	inch
W_1:weigh of upper limbs (left & right)	12.3	lb
W_2:weigh of trunk	55.5	lb

4. The displays and controls in figure 4-5 are well known equipments which are used in daily life.

4.1) Compare the advantage and disadvantage of the watches shown in figure 6, based on ergonomic concepts. (10 points)

4.2) Comment on two remote controls, and show your opinion about "design for friendly use". (10 points)

Figure 4 (a)

Figure 4 (b)

Figure 4 (a-b) : Watches in different design.

A Remote That Keeps It Pure and Simple
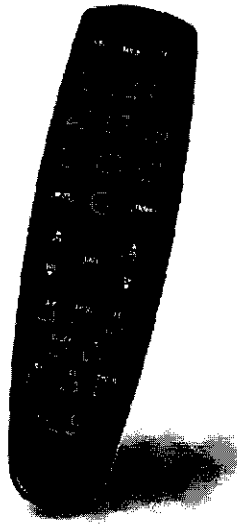**TV/Cable Box Universal Remote**

Figure 5 (a)
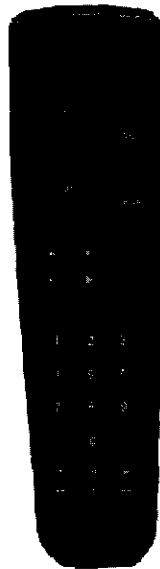
Figure 5 (b)

Figure 5 (a-b) : Remote controls in different design.

5. A 150 lb man is carrying a 20 lb bag in each hand while walking very slowly. All data from x-ray film for free body diagram (as shown in figure 6) are given in table 2. What is the reaction force on the head of the supporting femur when all of the weight is on one foot? (15 points)

Figure 6: Free body diagram for question #5.

Table 2: Important data for free body diagram in figure 6.

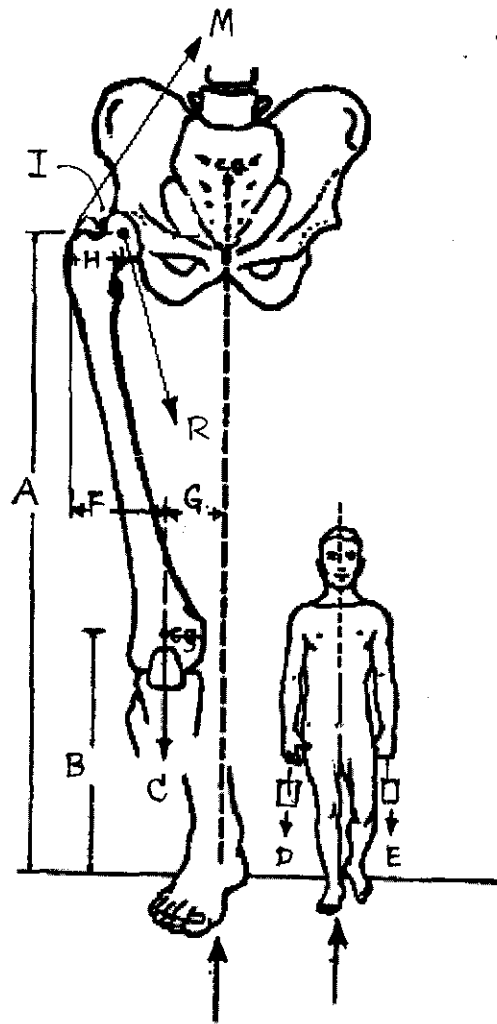| Symbol/data	Value	unit
A	35	INCH
B	16	INCH
C	28	LB
D	20	LB
E	20	LB
F	3	INCH
G	2	INCH
H	2	INCH
I	70	Degree

***********************GOOD LUCK***********************

		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

Decision Tree for Coupling Quality

Object Lifted
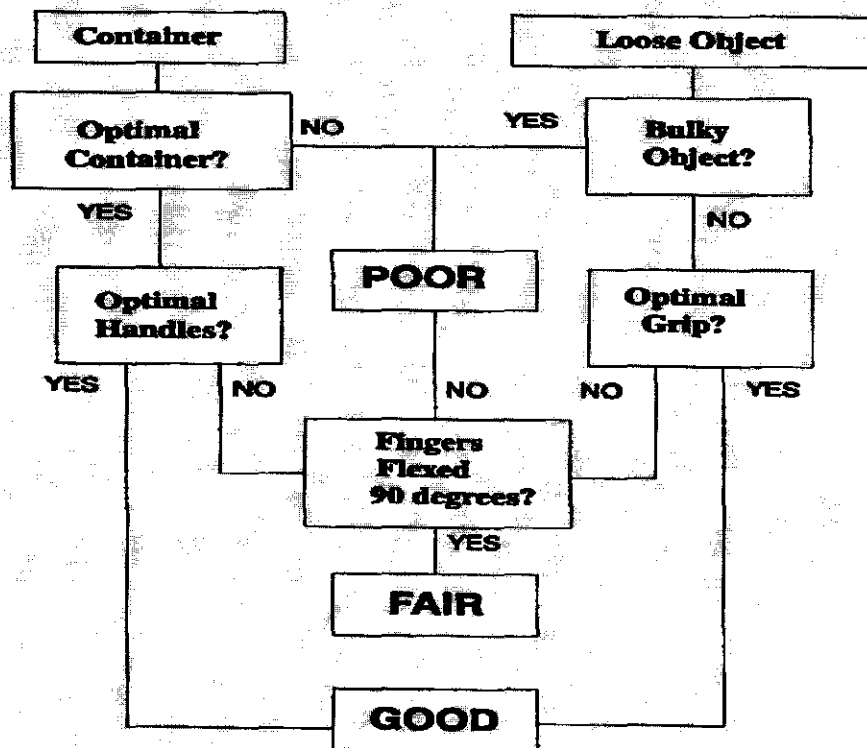
Table 5
Frequency Multiplier Table (FM)

Frequency Lifts/min (F) ‡	Work Duration					
	≤ 1 Hour		>1 but ≤ 2 Hours		>2 but ≤ 8 Hours	
	V < 30†	V ≥ 30	V < 30	V ≥ 30	V < 30	V ≥ 30
≤0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

†Values of V are in inches. ‡For lifting less frequently than once per 5 minutes, set F = .2 lifts/minute.

Table 7: Coupling Multiplier Table (CM)		
Coupling Type	Coupling Multiplier	
	V < 75 ᵍᴹ.	V ≥75 ᵍᴹ.
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

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

+1   +2   +2   +3   +4

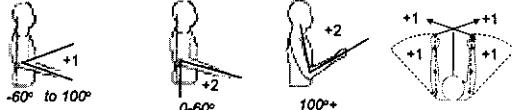-20° to +20°   > -20°   +20° to 45°   +45° to 90°   90°+
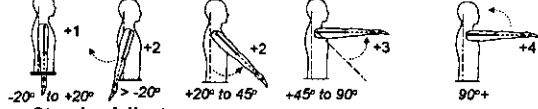
Step 1a: Adjust...
If shoulder is raised: +1;
If upper arm is abducted: +1;
If arm is supported or person is leaning: -1

Final Upper Arm Score =

Step 2: Locate LowerArm Position

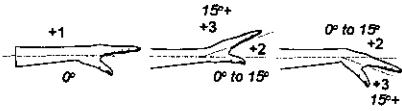+1   +2   +1 +1   +1 +1

-60° to 100°   0-60°   100°+

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

15°+ +3   0° to 15° +2   +1 +1

0°   0° to 15° +3 15°+   +2

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 twist 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 Force/load 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

Force/load 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 Wrist Twist 1	Wrist 1 Wrist Twist 2	Wrist 2 Wrist Twist 1	Wrist 2 Wrist Twist 2	Wrist 3 Wrist Twist 1	Wrist 3 Wrist Twist 2	Wrist 4 Wrist Twist 1	Wrist 4 Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C

	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Posture Score A = **+** Muscle Use Score = **+** Force/load Score = **=** Final Wrist & Arm Score =

Final Score=

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position
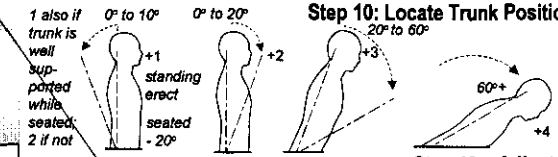
0° to 10° +1   10° to 20° +2   20°+ +3   in extension +4
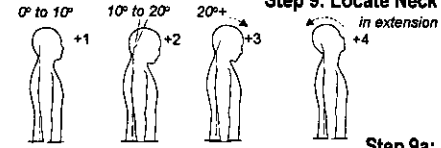
=Final Neck Score

Step 9a: Adjust...
If neck is twisted: +1; If neck is side-bending: +1

Step 10: Locate Trunk Position

1 also if trunk is well supported while seated; 2 if not

0° to 10° +1 standing erect seated - 20°   0° to 20° +2   20° to 60° +3   60°+ +4

= Final Trunk Score

Step 10a: Adjust...
If trunk is twisted: +1; If trunk is side-bending: +1

Step 11: Legs
If legs & feet supported and balanced: +1;
If not: +2

= Final LegScore

Table B

Trunk Posture Score

Neck	1 Legs 1	1 Legs 2	2 Legs 1	2 Legs 2	3 Legs 1	3 Legs 2	4 Legs 1	4 Legs 2	5 Legs 1	5 Legs 2	6 Legs 1	6 Legs 2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	9	9	9	9	9	9

Step 12: Look-up Posture Score in Table B
Use values from steps 8,9,& 10 to locate Posture Score in Table B

= Posture B Score

Step 13: Add Muscle Use Score
If posture mainly static or;
If action 4/minute or more: +1

= Muscle Use Score

Step 14: Add Force/load 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

= Force/load 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: _____   Date: / / __

Company: _____   Department: _____   Scorer: _____

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