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L4-/T-I/IPE Date: 17/09/2025

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-I B.Sc. Engineering Examinations 2023-2024

Sub: **IPE 407 (Ergonomics and Safety Management)**

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer **THREE** questions out of 4. Answering Question (1) is mandatory.

1. (a) How do flash point and fire point differ in their implications for fire hazard classification of industrial chemicals? **(5)(CO3)**

(b) A pressurized tank containing superheated propane ruptures suddenly. Outline the sequence of events from discharge to potential pool fire. What parameters influence whether the result is a vapor cloud explosion (VCE), flash fire, or BLEVE? **(10)(CO4)**

(c) A vapor cloud is released on a calm, cool night with slight surface wind (<2m/s) and moderate overcast. Identify the likely atmospheric stability class and discuss its implications for dispersion distance and public safety. **(10)(CO4)**

(d) A chemical spill creates a pool fire with a diameter of 1.5 meters. Predict the flame behavior, combustion completeness, and soot production. How would the risk profile change if the pool diameter doubled? **(10)(CO4)**

2. (a) List and explain the key elements required to conduct a HAZOP study, including guide words, nodes, and deviations. **(05)**

(b) A chemical process involves handling a toxic and flammable substance with a flash point of 18°C. Describe how the inherent hazard remains unchanged but the operational risk can be significantly reduced. Provide at least three safeguards that illustrate this distinction. **(10)**

(c) A confined vapor cloud ignites and produces a violent blast. Evaluate the combustion type (deflagration vs. detonation), resulting overpressure, and structural damage potential. What role does the DDT (Deflagration to Detonation Transition) mechanism play here? **(10)**

(d) You have been hired as a safety consultant to develop a Safety Management System (SMS) for a mid-sized manufacturing facility that produces electronic components. The facility has 150 employees and operates 24/7 in three shifts. Design a hazard identification and risk assessment process tailored for this facility. Describe how you will involve employees and use data from past incidents and inspections. **(10)**

Contd P/2

IPE 407

3. (a) Compare and contrast ABC and AD dry powder extinguishers in terms of chemical composition, application, and limitations. **(05)**

(b) Interpret the potential dangers of using a water (APW) extinguisher on a Class B or C fire, citing both thermal and electrical hazards. **(10)**

(c) Critically assess how TLVs (Threshold Limit Values) are determined and their limitations in ensuring worker safety. **(10)**

(d) Outline an effective PPE maintenance program in a chemical-handling textile plant, including inspection, cleaning, and replacement practices. **(10)**

4. (a) Rafiq is a 24-year-old software engineering student in his final semester. Over the last eight months, he has been working part-time as a remote web developer, often siting for-8 -10 hours a day at his desk without regular breaks. He recently started experiencing a persistent ache in his lower back and occasional tightness at the front of his hips. Despite no injury history, he feels his posture has worsened. **(15)**

When he stands upright, his lower back appears overly curved, and his abdomen slightly protrude. He also notices that when doing Legislature raises during workouts, his lower back lifts off the floor easily. He reports feeling weak when doing glute bridges and often struggles to engage his core during planks.

Rafiq visits the university's wellness center where the therapist observes a tilt of his pelvis during static posture assessment. The therapist also notes that his glutes do not activate properly during basic movements like squats and lunges.

(i) What problem is Rafiq likely suffering from?

(ii) Which muscles appear to be tight or overactive and weak or underactive for his case?

(iii) Suggest a corrective plan that addresses his problems.

(b) With proper examples, describe the three general principles for applying anthropometric data to specific design problems. **(10)**

(c) Discuss the relationship between sitting posture and intervertebral discoveries pressure. **(10)**

SECTION – B

There are **FOUR** questions in this section. Answering question 5 is MANDATORY.

Answer the rest of the **TWO** questions from quesion 6-8.

5. (a) Explain the seven stages of the sliding filament theory of muscle contraction with neat sketches. **(15)(CO1)**

Contd P/3

92

IPE 407
Contd... Q. No. 5

(b) Describe the purpose of extra oxygen intake after intense physical activity. **(5)(CO1)**

(c) In ergonomic design, lighting plays a critical role in ensuring visual comfort, safety, and productivity. Suppose you are tasked to design the lighting of a confined production facility where natural lighting is barely available. Apply your insights to develop a proper lighting plan for the facility. **(15)(CO2)**

6. (a) Discuss the health effects of manual material handling (MMH) on the human body. **(5)**

(b) Contrast among the biomechanical, physiological and psychophysical approaches of assessing manual material handling tasks. Which one seems more practical and straightforward to use in real life to you? **(15)**

(c) Suppose you have to assess the posture of a high-frequency job performed by workers at a warehouse. The posture is shown in Fig. 6(c). The following information is available regarding the job. **(15)**

- The shoulder is raised during this posture.
- The wrist is at a 10° angle with respect to the lower arm and bent from the midline.
- The neck is in extension with respect to the trunk.
- The load is weighted 10 lbs.
- The posture is repeated 5 times in a minute.

Determine the step-by-step Rapid Upper Limb Assessment (RULA) score for this posture. Assume any value rationally from the figure that is not explicitly mentioned. You have to demonstrate each and every score leading to the final RULA score with explanation.

Fig. 6(c)

Contd P/4

IPE 407

7. (a) Differentiate between active tension and passive tension in a muscle. Explain how these tensions change with the increase in length of the muscle with a proper diagram. **(10)**

(b) Illustrate the factors affecting the consumption of energy during work with appropriate examples. **(20)**

(c) You are analyzing the schedule of a large e-commerce warehouse's order fulfillment team. The task involves continuous walking, squatting, and lifting packages. The following has been recorded: **(5)**

- Task energy expenditure: 5.9 kcal/min
- Peak task demand: 6.8 kcal/min
- Acceptable continuous workload: 3.9 kcal/min
- Resting rate: 1.5 kcal/min
- The company runs on a 120-minute shift cycle

How many minutes of rest should be incorporated in each cycle to ensure worker well-being?

8. (a) Explain elaborately on the consequences of not maintaining a straight wrist while using hand tools. **(15)**

(b) Write short notes on: **(20)**

(i) Hand-Arm Vibration Syndrome (HAVS)

(ii) Frostbite

(iii) Hearing Protection Device (HPD)

(iv) Disc Degeneration

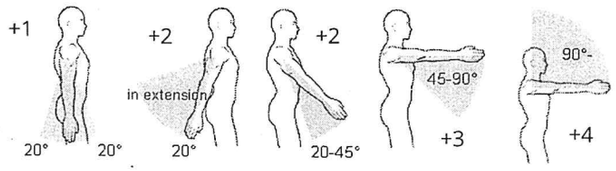
ERGONOMICS PLUS

RULA Employee Assessment Worksheet

Task Name: Date:

A. Arm and Wrist Analysis

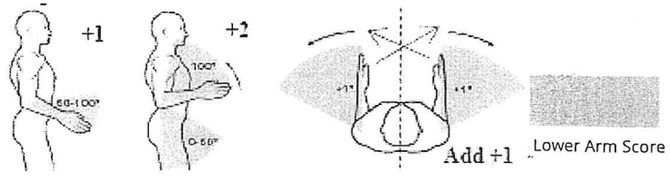
Step 1: Locate Upper Arm Position:



Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

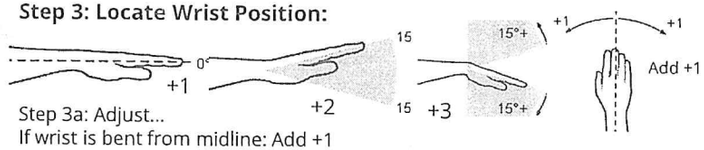
Step 2: Locate Lower Arm Position:



Lower Arm Score

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:



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

Step 4: Wrist Twist:

If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Wrist Twist Score

Wrist Score

Step 5: Look-up Posture Score in Table A:

Using values from steps 1-4 above, locate score in Table A

Posture Score A

+

Step 6: Add Muscle Use Score

If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

+

Step 7: Add Force/Load Score

If load < .4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score

=

Step 8: Find Row in Table C

Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**.

Wrist & Arm Score

Scores

Table A

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

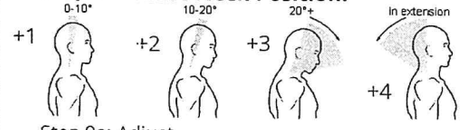
Wrist / Arm Score	Neck, Trunk, Leg Score 1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

RULA Score

B. Neck, Trunk and Leg Analysis

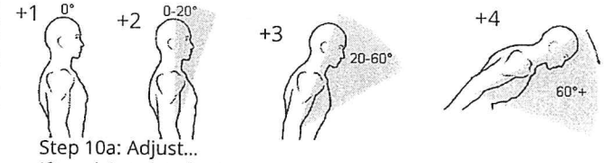
Step 9: Locate Neck Position:



Neck Score

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

Step 10: Locate Trunk Position:



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

Trunk Score

Step 11: Legs:

If legs and feet are supported: +1
If not: +2

Leg Score

Table B: Trunk Posture Score

Neck Posture Score	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	8	8	
5	7	7	7	7	8	8	8	8	8	8	8	
6	8	8	8	8	8	8	8	9	9	9	9	

Step 12: Look-up Posture Score in Table B:

Using values from steps 9-11 above, locate score in Table B

Posture B Score

+

Step 13: Add Muscle Use Score

If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

+

Step 14: Add Force/Load Score

If load < .4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score

=

Step 15: Find Column in Table C

Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C**.

Neck, Trunk, Leg Score