

## National Exams December 2018

**17-Ind-B5, Ergonomics**

3 hours duration

*Instructions:*

- ◆ There are eight (8) pages to this exam with three parts and a total of four (4) questions. You must answer a total of 3 questions (all of Part A which is mandatory and Part B where you choose one of two questions).
- ◆ The NIOSH tables are produced at the end of this exam as Appendix 1 for your use.
- ◆ A table of manual material handling assist devices is provided as Appendix 2 for your use.
- ◆ This is an **OPEN** book exam.
- ◆ Any non-communicating calculator is permitted.
- ◆ **Please use point form to answer all questions.**
- ◆ If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made;

## Marking Scheme

<i>Question Number</i>	<i>Total Possible</i>	<i>Grade</i>
<b>Part A: General – mandatory</b>		
1.	40 marks	
2.	40 marks	
<b>Part B: <u>Choose 1</u> question to answer from questions 3 or 4. <u>DO NOT</u> answer both questions</b>		
3.	20 marks	
4.	20 marks	
<b>Total</b>	<b>100 marks</b>	

**Part A: Mandatory**

[40 marks] 1. A large beer processing and packaging plant would like to expand and building a new state-of-the-art loading facility. In this new facility, they would like to have trucks move through the facility on a conveyor and be loaded with various beer products for delivery, including cases of different varieties of beer in bottles, cans, and large (50 litre) and small (20 litre) kegs. All products are prepared in the processing plant and then moved into refrigerated storage facilities in the loading area using automated conveyors and human operators. From there, orders are filled by an automatic pick system that is also controlled by human operators. Orders are loaded into appropriate cases (e.g., bottles into boxes, cans into recyclable plastic holders) and then onto to palettes, wrapped and labeled by the automatic system. The palettes are then inspected for completeness and accuracy by human inspectors before being released for shipping.

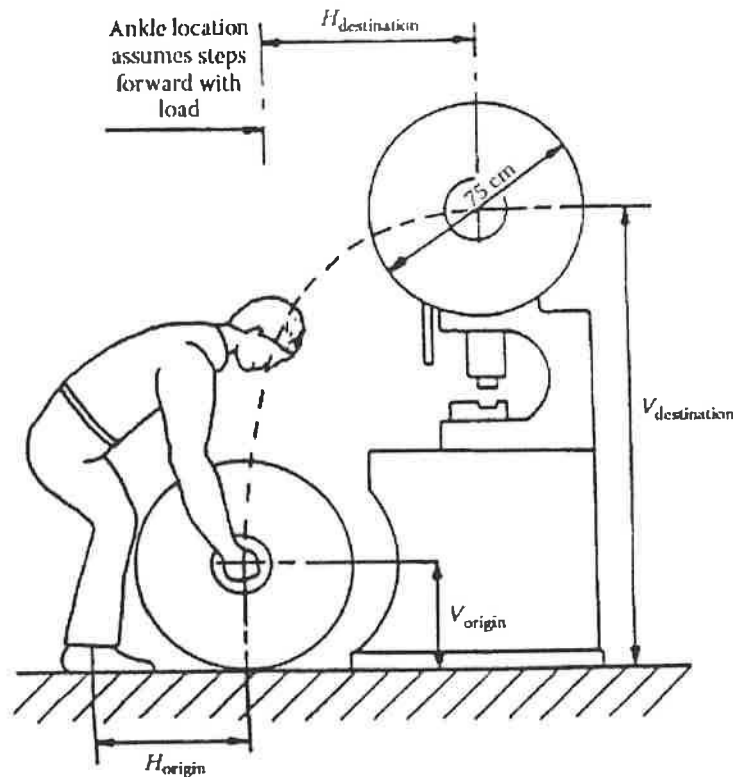
It is a unique facility because trucks will be brought in on conveyors and shuttled to various loading points in the facility so that they can be loaded and unloaded efficiently. Loading will still be carried out by human forklift operators that move the palettes onto the truck. More than one truck can be processed at any one time because there will be multiple conveyor paths through the facility (note: the truck engines will be turned off during this loading process).

Because it is important to keep the product at a temperature of 4° C at all times, workers will be working a cold temperature environment. In addition, there are many conveyors and automatic systems working in this facility causing potential issues for workers with noise and vibration.

You have been asked to advise the company on the physical environment issues/problems and make recommendations on design options to overcome these issues. The company is willing to consider automating tasks that are considered too hazardous.

- a) [10] Outline the various considerations elements and environmental factors that are required to properly characterize this physical environment for all of the tasks involved. Justify why each is important in this case.
- b) [5] Explain the checklist method for human factors analysis. How could this method be applied in this situation? What modifications would you make to a standard human factors checklist for this particular application?
- c) [10 marks] Other than a checklist, describe two possible human factors methods you could use to assess the human factors and ergonomics situation in this plant. Explain the costs and benefits of each method? Which method identified from question 1b and 1c would you recommend and why?
- d) [10 marks] Provide recommendations on physical ergonomic accommodations that would be suitable for this environment. Justify your recommendations and provide the appropriate environmental data that is appropriate for use with this design/facility for each task specified in part a of this question. Provide a sketch of an example system and label all of the physical elements (including any required limits).

- [40 marks] 2. The normal job of a punch press operator is to feed small parts into a press and remove them. Once per shift the operator is required to load a heavy reel of supply stock from the floor to the machine from a hand height of 35 cm to a height of 170 cm, as illustrated in Figure 1. The distance from the operator to the hand hold of the reel is 58 cm. The reel is 75 cm in diameter and weighs 25 kg. Assume that the operator lifts the reel in front of the body as shown, and that to load the reel the operator must exercise significant control at the destination of the lift.



**Figure 1:** Posture and lift to load new supply stock reel.

- [10 marks] Calculate the RWL and LI for the origin and destination lift using the NIOSH tables attached to this paper as Appendix 1.
- [10 marks] What are the safety issues and risk factors to the worker in this job? What anatomical structures are affected?
- [10 marks] Using the table of material handling devices attached to this exam as Appendix 2, what lift assist devices would you recommend in this situation – there may be more than one possible? Justify these recommendations.
- [10 marks] What other possible human factors resolutions would you recommend to reduce the manual materials handling risks and justify why these resolutions are appropriate?

**Part B: Choose one question to answer from questions 3 or 4.**

[20 marks] 3. A common model of error used in ergonomics analysis is Reason's model of error as seen in Figure 2.

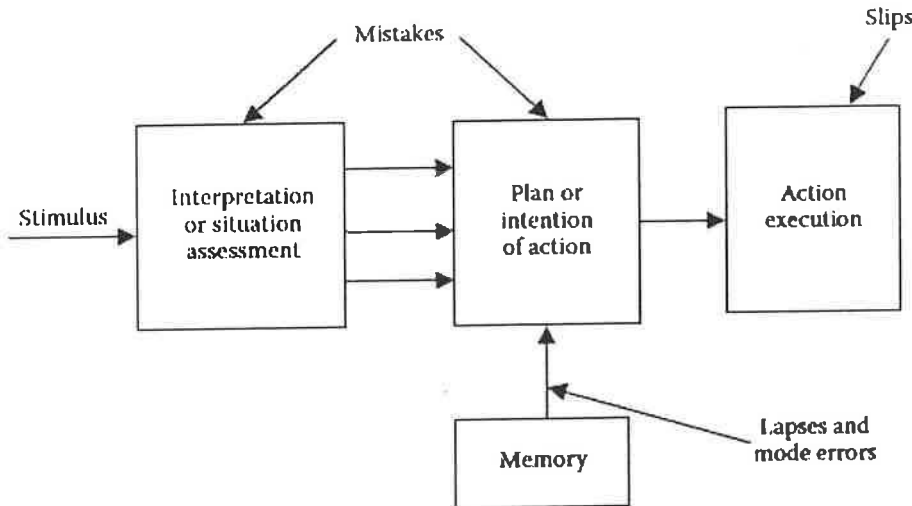


Figure 2: Reason's model of human error (1991)

The following is a list of errors that can occur by operators of a hauler machine used in mining to move around ore.

1. Hauler machine is not returned for service according to schedule
2. Setting off with parking brake on
3. Operator driving hauler machine while sitting on rear bumper
4. Misreading of displays
5. Operator leaning out of cab while traveling
6. Insufficient warning to people behind hauler machine while operator is backing up
7. Instability prevents effective use of fire extinguishers
8. Incorrect operation of machine controls
9. Tires not maintained according to accepted practice
10. Operating the hauler machine too fast when fully loaded.

- a) [10 marks] Identify the error type for each error using Reason's error model seen in Figure 2 and justify why it is that type of error.
- b) [10 marks] Explain what type of human factors interventions or action could be taken to correct each error.

[20 marks] 4. Controls and displays

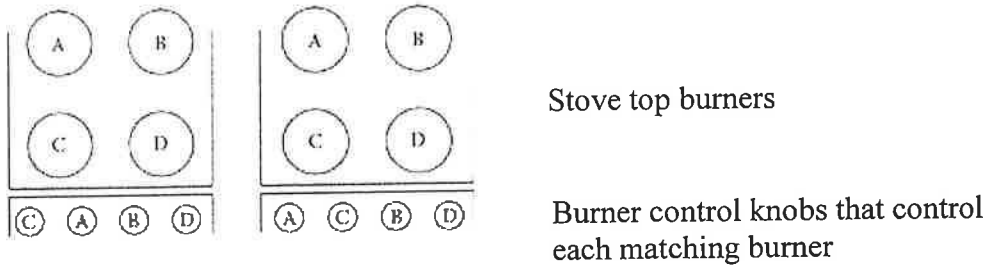


Figure 3: Common layout of controls for top burners of a domestic stove

- [5 marks] Identify the human factors issues/risks with the two layouts in Figure 3. Explain why these are issues/risks.
- [10 marks] What recommendations/alternative solutions would you make to the manufacture of these stoves in order to reduce the issues/risks you identified. Sketch each of your solutions.
- [5 marks] Carry out a cost benefit/analysis for one of your solutions.

**Appendix 1: NIOSH Work Practices Guide to Manual Handling Formula Multipliers**

These formulas eliminate the need for you to do the detailed calculations in the formula:

- $RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$
- LC is 23kg or 51 lb.
- You still need to figure the correct values of H, V, D, A, coupling, etc. and determine the multipliers.
- $LI = \text{Load weight} / \text{Recommended Weight Limit} = L / RWL$  Where Load Weight (L) is the object lifted (kg or lb)

**Horizontal Multiplier**

H in	HM	H cm	HM
≤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

**Table 2  
Vertical Multiplier**

V in	VM	V cm	VM
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	.99
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

**Table 3  
Distance Multiplier**

D in	DM	D cm	DM
≤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		

**Table 4**  
**Asymmetric Multiplier**

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

**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**

Coupling Type	Coupling Multiplier	
	V < 30 inches (75 cm)	V ≥ 30 inches (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

## Appendix 2

### A List of Manual Materials Handling Devices and Their Possible Uses in Manufacturing

	Horizontal (H) or Vertical (V) Transportation	Receiving	At Workstation	Between Workstations	Testing	Packaging	Warehousing
Conveyor	H	x	x	x	x	x	x
Snake conveyors (easily movable)	H	x					x
Ball transfer table	H				x	x	
Carts	H		x	x	x		
Carousels	H		x	x	x		
Turntables	H			x	x		
Cranes	V	x	x	x	x	x	x
Hand trucks	H	x		x			x
Forklift trucks	H, V	x	x			x	x
Gravity feed conveyors/slides	H, V				x	x	
Automatic storage and retrieval	V, H	x					x
Stackers	V, H	x					x
Lift/tilt table	V		x		x	x	
Levelators	V		x		x	x	
Scissor table	V		x		x	x	
Vacuum lifting devices	V	x	x			x	x
Self-leveling table	V		x		x		
Adjustable table	V		x		x		
Overhead balancer	V		x		x		