National Exams December 2019

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 chose one of two questions).
- The NIOSH tables are produced at the end of this exam as Appendix 1 for your use.
- This is an open book exam; all notes, books and non-communicating calculator are 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;
- Any non-communicating calculator is permitted.
- No pagers, cellular telephones, smartphones or other communication devices are permitted in this exam.

Marking Scheme

Question Number	***Total Possible***	***Grade***
Part A: General – mandatory 1. 2.	 40 marks 40 marks	
Part B: Choose 1 question to answer from questions 3 or4. Do not answer both questions		
3.	20 marks	
4.	20 marks	
Total	**100 marks**	

Part A: Mandatory

40 marks] 1. Displays and controls

You are working for a yogurt making company that wants to modernize its control and display panels for its mixing stations where plain yogurt is mixed with flavouring. At the mixing stations the liquid yogurt mixture, a thickening agent, and flavouring are poured into large cooled mixing vats. A mixer arm is lowered into the vat and rotated at 20 rpm until the flavoured yogurt is the appropriate density/thickness. In order for the yogurt mixture to thicken properly, the vat must be maintained at a temperature of 2° C. However, in order for the yogurt to be packaged it must be soft and fluid enough to be pressed through a 0.5 cm nozzle into small snack-size containers (not completely thickened but not a liquid). Careful monitoring, timing and control are required to accomplish the making and packaging of the flavoured yogurt products. The old system used only analogue controls (mechanical buttons and knobs), lights and dials. The company wants to upgrade to modern digital controls and displays for monitoring, increasing/decreasing, and setting the following variables: temperature, pressure, volume, inflow/outflow, mixture colour and density of the yogurt mix as well as the temperature and speed of the mixing arms and vats. The new system will still need humans to be involved in the monitoring and controlling tasks because adjustments must be made to the mixture if density and colour are incorrect.

a. [20 marks] Provide a design recommendation for the new digital control system and justify your reasoning. Ensure that you include a drawing of your recommendations.
b. [10 marks] Explain the main components of the human perceptual and cognitive system that would be involved in monitoring and manipulating this control and display system.
c. [10] The company wants to locate the control panel and its human operator close to the mixing vat area so adjustments can be made during the mixing process as required. In the area, the environmental temperature is kept low to ensure that the yogurt is always maintained at a cool temperature (no greater than 4° C). The packaging conveyor runs through the mixing area so that vats of mixed yogurt can be emptied directly into the snack packages through a system of pneumatic hoses and nozzles. Workers can be working in a cold temperature environment. In addition, the conveyor, mixer and pneumatic filling system are noisy and generate vibrations through the floor. Outline the various considerations, elements and environmental factors that characterize this physical work environment. What adverse effects could be experienced by the human operators?

[40 marks] 2. Manual materials handling

A worker lifts boxes filled with twenty packages of car brake pads from a conveyor onto a pallet that will be shipped to different car companies around the world. The boxes weigh 22 kgs each and are 50 cm (width) x 25 cm (length) x 20 cm (height). The worker grasps the middle of each box as there are no handles. The height of the pallet is 85 cm above the floor and the height of the conveyor is at 70 cm above the floor. The conveyor and pallet are 10 cm apart. The worker must turn 30o each time a box is transferred (the conveyor is at a 30o angle to the pallet). The worker performs 4 lifts per minute.

a. [10 marks] Calculate the RWL and lifting index for the lifting task. Show all of your work.
b. [6 marks] Comment on the safety of this task and what are the main risk factors to workers?
c. [6 marks] What are three problems with training in safe lifting techniques? Why are these problems?
d. [8 marks] What are three positive and three negative impacts of wearing an abdominal belt for lifting? Would you recommend one for workers in this company, why or why not?
e. [10 marks] What other ergonomic/human factors recommendations would you make to the company to improve the conditions for workers doing this lifting task? What impact could these recommendations have, if implemented?

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

:0 marks] 3. Measures for Human Factors

As publically available drone technology improves and becomes technically more reliable and able to be operated at far distances. In the television industry drones are being used to capture aerial shots to avoid needing to use an actual helicopter. Operators use a remote control with four joysticks, a number of buttons to control the drone operations and a screen showing the camera views (see Figure 1). Today, a human operator needs to control take-off and landing, as well as make in-flight adjustments to avoid unpredictable problems such as birds, moving objects in the sky and on the ground, and uneven landing surfaces. It is also important that the operators maneuver the drone in a timely manner in order to film the action that is occurring; drone delays cause additional expenses because scenes being filmed may need to be re-filmed. Errors also can cause similar problems; drone operators must be able to film and keep up with the action in a timely and accurate manner, take direction, make modifications and review the images being shot by the drone camera on-the-fly. In order to provide training in efficient and effective operation of a drone, you have been asked to determine various Human Factors/Eronomic measures that could be used to assess the human performance aspects of flying a drone.

Figure 1: Drone control (courtesy of Yuneec Typhoon H, 2019).

Outline a measurement strategy for assessing the human operators of the drones.

a. [10 marks] Which metrics would you include in your strategy and why would each metric be useful to the drone operators and the television production company (for what purpose could they be used)?
b. [10 marks] Discuss how each metric could be measured. What hardware/software could be used?

[20 marks] 4. Worker injuries

You have been asked to assist a large company with addressing health and safety issues experienced by their full-time office staff. These individuals sit at a desk for most of the work day interacting with a computer. Movement of their body involves typing on a computer keyboard, using a mouse, looking at two computer screens on a desk, moving papers around on a desk with their hands and arms, occasionally using office supplies such as a stapler and paper clips. One of the computer screens is a touch screen that workers must use to manage their electronic documents (e.g., save, copy/paste, move, open). Workers use specialised touch screen software designed by the company for office workers to manage their electronic files. Touch screen controls consist of selecting, dragging and dropping, zooming/contracting, scrolling and deleting using the fingers in the hand similar to the way in which touch screens work with mobile devices.

a. [6 marks] List and briefly describe two different types of work injury that could occur in this situation and the human factors concern(s) associated with them?
b. [8 marks] Create a table that shows what tasks are most affected by each injury and why? How would you determine where to place the touch screen in order to minimize possible injuries resulting from its use?
c. [6 marks] For each of the affected tasks from part b of this questions, what would you recommend as a job modification to alleviate the problem(s)?

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 x HM x VM x DM x AM x FM x 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= Load weight / Recommended Weight Limit = L / RWL Where Load Weight (L) is the object lifted (kg or lb)

Horizontal Multiplier

H	HM	H	HM
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

Table 2
Vertical Multiplier

V	VM	V	VM
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	.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	DM	D	DM
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		

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