National Exams Dec. 2014

98-Ind-B5, Ergonomics

3 hours duration

Instructions:

- There are seven (7) pages to this exam with three parts and a total of five (5) questions. You must answer a total of 4 questions (Part A, **and** two other questions from part B, **and** part C).
- The NIOSH tables are produced at the end of this exam for your use.
- This is an open book exam; all notes, books and 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;
- Any non-communicating calculator is permitted.
- No pagers, cellular telephones, Blackberries or other communication devices are permitted in this exam.

Marking Scheme

Question Number	*Total Possible*	*Grade*
Part A: General - mandatory	25 marks	
Part B: Choose 2 questions to answer from questions 2-4. Do not answer all three questions		
2.	20 marks	
3.	20 marks	
4.	20 marks	
Part C: Case Study - Mandatory	35 marks	
Total	**100 marks**	

Part A: Mandatory

25 marks] 1. You have been asked to design a new ticket dispensing machine for a major public transportation system that includes buses, streetcars, subways, and an intercity railway. The system is to be designed for three possible purchasing options: 1) Ride any time/anywhere/any place – most expensive but most flexible. This type of ticket is transferable but only one person can use it at a time. Also, riders can purchase monthly, weekly or daily versions of this type of ticket. The prices will vary depending on which option is selected; 2) Pay by specific zone and there are three possible zones. In this option, the price of the ticket will depend on the proximity of the zone to the purchaser. For example, it a rider is in zone 1 and wants to get to zone 2, the price is the same as going from zone 2 to zone 3. However, the price for riding from zone 1 to zone 3 (across 2 zones) is more than cost of riding across one zone to its neighbour. Riders can use any mode of transportation with this ticket type. The prices will vary for each zone but will be less expensive than the ride any time ticket; and 3) Purchase a one-way ticket on only one mode of transportation (e.g., bus only) within one zone. This is the least expensive but most restrictive option.

Riders should be able to purchase these tickets with a credit card, a debit card or cash. Once the transaction is complete the rider will received a printed bar-coded ticket.

a. [8] Generate a list of typical tasks that users would carry out to purchase a ticket. Include the types of decisions that must be made by the purchaser.
b. [17] Create a paper mock-up/sketch of the control and display system for the ticket. Ensure that you can accommodate as many potential users as possible (e.g., you need alternatives for each control and display). Justify your reasoning for each design decision based on common human factors principals of displays and control types (e.g., if using knobs, knob diameter, turning force, labeling, grouping of controls, etc. should be used in this justification). Explain the population demographics that your system will accommodate.

Part B: Choose two questions to answer from questions 2-4.

[20 marks] 2. A worker must unload trays of cookies as they emerge from an oven. He picks up a tray directly in front of him, turns 45° to one side and places the tray on a conveyor. A full tray of cookies weighs 10 kg. He does this 4 times per minute for 8 hours. You have been asked to investigate the task and have taken the following measurements with a tape measure.

The distance of the load from the mid-point of the body is = 50 cm, height of the hands above the floor = 60 cm; distance through which the load is lifted = 60 cm. Use the tables provided with this exam.

a. [5] Calculate the Recommended Weight Limit and Lifting Index for this task using the NIOSH formula. Justify your assumption for coding multiplier.
b. [5] Is this task safe? What are the risk factors for a worker performing this task (e.g., what injuries might this worker incur)?
c. [15] Explain the advantages and disadvantages for at three different solutions for making this task safer? Show the new RWL for solutions where appropriate.

!0 marks] 3. How would you implement a musculoskeletal disorders prevention program for an electronics manufacturing company? Explain the specific steps you would take and why. In this company, people are required to:

i) Work with small electronic components (e.g. integrated circuits, cpu, resistors, capacitors and wiring, and tools when there is a quality assurance problem with the production robots. This occurs about once every two weeks.

ii) Package the electronics into boxes for shipping. This means placing a board in a special static bag, placing in a protective package and loading into a box for shipping. Twenty-four circuit boards weighing 250 grams each fit into one box and it is expected that workers fill 1 box every 15 minutes.

iii) Move materials around the plant with fork lifts and by hand.

iv) Load small components into bins for use in fabricating circuit boards; and

v) Unload supplies/small components being delivered.

!0 marks] 4. Outline the general principles of computer work station design. Draw and label the elements of a multipurpose station that would allow for basic computer-based and paper-based office work along with the variables that must be adjustable, and the amount of adjustability that should be provided.

35 marks] Part C: Case study

A large meat 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 meat products, including cases of processed meats such as ham and bologna, vacuum packaged meat cuts such as roasts and steaks, as well as boxed meats such as hamburgers and meatballs. 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 onto palettes, wrapped and labeled by the automatic system and then inspected for completeness and accuracy by human inspectors.

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 fork lift 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 human factors considerations required to properly characterize this physical environment for all of the tasks involved.

b. [15] Provide recommendations on physical ergonomic accommodations that would be suitable for this environment. Justify your recommendations and provide the appropriate environmental data that is needed for 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).

c. [10] Describe the evaluation process you would carry out during/after the construction process to ensure that your recommendations are followed/successful. Ensure that you specify what type of evaluation to use at what time during the construction process, what equipment you would used, and justify the timing and the methodologies selected.

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