National Exams Dec. 2012

04-Bio-B11, Ergonomics

3 hours duration

Instructions:

- There are nine (9) pages to this exam with two (2) parts and a total of five (5) questions. You must answer a total of 4 questions (question 1 **and** two other questions from part A and all of part B).
- 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 not allowed in this exam.

Marking Scheme

Question Number	*Total Possible*	*Grade*
Part A: General		
1. **- mandatory**	25 marks	
Choose 2 questions to answer from questions 2-4.		
2.	20 marks	
3.	20 marks	
4.	20 marks	
Part B: Case Study - Mandatory	35 marks	
Total	**100 marks**	

Part A: General: Mandatory

1. [25 marks] You are working for an ice cream and sorbet making company that wants to modernize its control and display panels for its mixing stations. At the mixing stations the liquid ice cream mixture is poured into large cooled mixing vats. A mixer arm is lowered into the vat and rotated at 20 rpm until the ice cream is the appropriate density/thickness. In order for the ice cream mixture to thicken, the vat must be maintained at a temperature of -5°C. However, in order for the ice cream to be packaged it must be soft and fluid enough to be pressed through a 3 cm nozzle (not completely frozen but not a liquid). Careful monitoring, timing and control are required to accomplish the making and packaging of the ice cream products. The old system used only analogue controls (mechanical buttons and knobs), lights and dials. Controls and displays are required for monitoring, increasing/decreasing, and setting the following variables: temperature, pressure, volume, inflow/outflow, and density of the ice cream mix as well as the temperature and speed of the mixing arms and vats.

    a. [15] Provide a design recommendation for the new control system and justify your reasoning. Ensure that you include a drawing of your recommendations.
    b. [10] Explain the main components of the human perceptual and cognitive system that would be involved in monitoring and manipulating this control and display system.

Part A: Choose 2 questions to answer from questions 2-4.

20 marks] 2. **Cameron's Craft Shop**

2. To avoid damage to work-in-progress, it is the custom of Cameron's workshop to store projects on elevated auto-feed shelving. Once a shelf is emptied, mechanical automation moves the shelf back to the top of the stack and the lowest full shelf is lowered to be 165 cm off the floor. The workers grasp the objects one at a time, lower them manually to 127 cm and insert them into the equipment. Show all of your calculations. Please refer to the NIOSH tables at the end of this exam.

   a. [5] The craftspeople do this lowering operation in a batch taking about 90 minutes, and they each have about 360 units to transfer in that time. The units are handled one at a time, with good coupling, directly in front of the body. You observe and determine that the horizontal distance is 33 cm at the lower height, but 51 cm on the shelf. What is the NIOSH RWL (recommended weight limit) for the lowering task? Refer to the NIOSH tables at the end of this exam.

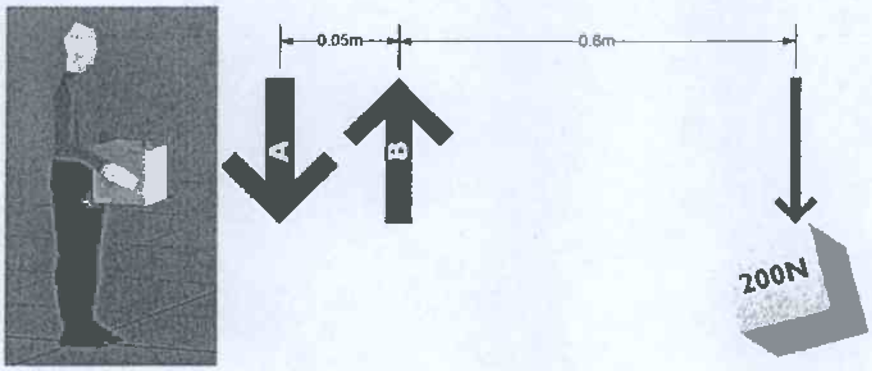
   b. [5] In Cameron's workshop, another worker must place these objects on the 165 cm shelf. The incoming units are on a conveyor that is 81 cm high. One object arrives every five minutes for the whole eight hour shift. In between these lifts, the worker is doing light activities such as sanding, dusting, painting and quality inspection. When the next object arrives, the worker reaches 15° to the left to grasp the object from the conveyor and turns 15° to the right to place it on the shelf. On the conveyor, the workers can get 25 cm horizontally from the object to be lifted. The shelf is 165 cm high and at the point of placing the object on the shelf, the object is 51 cm horizontally from the body. What is the NIOSH RWL for the lifting task?

   c. [5] Cameron called you in because the workers have complained that these objects that weigh 16 kg are too heavy. She had been using a 18 kg lifting limit that she read in a safety magazine years ago, and thought this weight was better than okay. You determine that the NIOSH formula results are relevant to this task. What recommendations/solutions would you provide. Provide a diagram(s) of possible solutions.

   d. [5] Cameron decided to try reducing the shelf to 140 cm and limit the lifting task to 2 hour periods. In addition, she redesigned the objects to try to reduce the weight. Unfortunately, the coupling is now poor. She is aiming for a LI no higher than 5 cm either lift or lower. What is the maximum weight for the redesigned object?

20 marks] 3. Lifting: Use the following diagrams to answer the questions on the next page.

The centre of gravity of the box is 60cm forward of the spine. The diagram represents the L4-L5 joint.



a) [5] What is the force labelled A on the diagram above.
b) [5] What is the force labelled B on the diagram above.
c) [3] Explain what the force labelled A represents in this lifting task.
d) [7] Describe the important elements of the human back/spine system that are of concern for lifting and carrying tasks. What lifting style would your recommend for this lifting this load. Discuss the impact on the occupational health and safety of workers when using different lifting styles (what types of injuries and strains could be expected or avoided and why).

20 marks] 4. Human-computer interfaces and cognition

a. [5] Why is user-centred design important in designing computer interfaces? Note: ensure that you specify what a computer interface is within your answer.
b. [10] How do we take advantage of human cognition in designing human-computer interfaces? Outline the major components of a model of the human cognition system that are responsible for a user's ability to interact with a computer interface.
c. [5] Explain an example from your own experience where a computer user interface design failed (or requires significant improvements) to consider users and their tasks. Using your model of human cognition, show why this design failed (provide a diagram).

35 marks] Part B: Case study mandatory

You have been asked to advise a large pizza making and delivery chain on how to reduce the number of back, neck, shoulder and arm/wrist strains that staff are experiencing and complaining about. Pizzas are made according to customer specified orders. Pizza sizes range from small (20 cm diameter) to extra-large (55 cm diameter). These orders can be received by telephone or through an online ordering system. The order is then displayed on 48 cm flat screen monitors placed at 200 cm above the pizza-making workstations.

During an eight-hour shift, staff are required to stand at and walk along a counter that is 87 cm high (recommended standard) to make custom pizzas. First, one worker removes the pizza dough from a refrigerator and places it on the counter at the dough processing station. The counter is 87 cm high (countertop from floor), 61 cm wide (from front to back wall) and 183 cm long (length of counter segment from side to side). The worker kneads, molds and flattens the dough ball to the diameter of the order, and then places the dough on a flat tray. The worker then turns 90° to face a counter perpendicular to the first counter (second counter is also 87cm high, 91 cm wide front to the back wall and 367 cm long) and adds the sauce and spreads it on top of the pizza dough.

A second worker then takes the tray and places the remaining ingredients on the pizza by sliding the tray along the counter and picking out ingredients that are contained in bins that are 20 cm wide, 30 cm front to back and 20 cm deep. The bins are located at the back of the counter and are placed such that the top opening of the bins is flush with the counter. The bins are placed along the counter in no particular order. The worker must reach over the counter, reach into the bins, and pick up the various ingredients (e.g., cheese, pepperoni, tomatoes, olives, onions and green peppers) and then place them on the pizza dough/tray. Figure 1 shows the layout and dimensions of the pizza-making operation.

Once the pizza is finished (a pizza takes on average about 5 minutes to make), the worker places the pizza in a specialised conveyor pizza oven to cook. The oven located at 183 cm across from the pizza making counter. The height of opening to the pizza oven where the pizza is inserted is 91 cm. A pizza plus the pan weighs approximately 2 kg. It takes approximately 15 minutes for the pizza to be cooked. The ambient temperature in the pizza making and baking area is 26° C, although it is about 2 degrees warmer at the entrance and exit of the pizza oven.

There are two 15 minute breaks and a one hour lunch break where the person can sit down either in a break room located away from the pizza making and baking area in the restaurant or outside. Worker demographics include: standing stature ranging between 150 - 200 cm, weight between 55 – 120 kg, age range between 18 and 65 years, and it is a mostly female work force. About 30 pizzas per hour are processed in this particular restaurant.

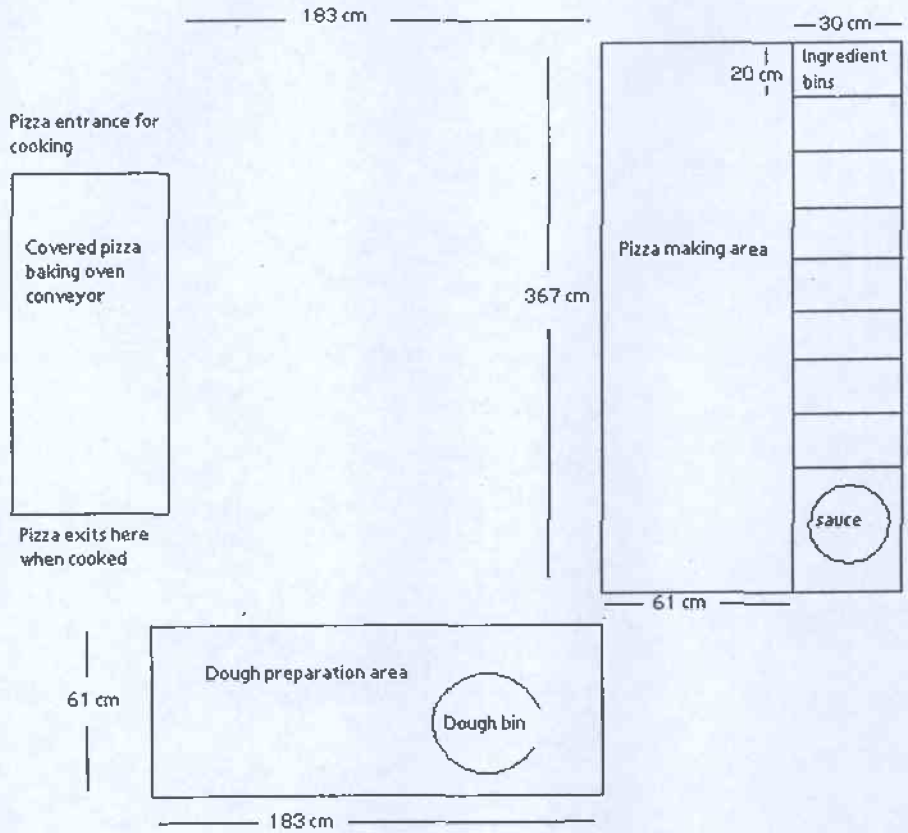


Figure 1: Drawing of layout and dimensions for pizza-making operation. Not to scale.

Assume that you have a fairly limited budget for this project, therefore you can modify but not gut and reconstruct the kitchen.

a. [5] Describe the types of manual materials handling tasks that staff would be carrying out. Identify the ergonomic issues that may appear with each of these tasks for this particular example. Identify potential sources of error in the pizza making tasks.
b. [10] Provide recommendations on physical ergonomic accommodations that would be suitable for the staff. Justify your recommendations and provide the appropriate anthropometric data that is appropriate for use with this design. Provide a sketch of an example workstation and label the dimensions (including any required ranges of adjustment). Indicate on your sketch the population proportion that you believe will be satisfactorily accommodated by these dimensions. The manager would like to begin to accommodate workers in wheelchairs. What adjustments would you make to the existing workstations for these accommodations? Are these adjustments adequate to accommodate employees using wheelchairs? Identify additional wheelchair-accessibility adjustments that you would make if the company was building a new branch location and was not constrained by budget limitations of retrofitting.

c. [10] Provide recommendations on other factors that would assist in reducing any potential errors (identified in part a of this question) made and strain injuries occurring, and increase the comfort/task performance of the pizza-making staff. Identify the important variables to measure/track for the main pizza-making tasks and how these are measured (e.g., instruments used, units of each variable). Specify how to determine the appropriate level of each condition for this workplace that would minimize the number of errors. How would you ensure that your recommendations provide long term solutions? Provide examples.

d. [10] Describe the evaluation process you would carry out during/after the renovation process to ensure that the accommodations are successful. Ensure that you specify what type of evaluation to use at what time during the renovation. 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