ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2015 SESSION

Open-book examination Calculators : Only authorized models Duration : 3 hours

14-IN-B2 Ergonomics

1) This task consists in assembling the six small components of disposables infusion sets used in hospitals. This task, exclusively performed by women, is done in a sitting position.

   a) During a discussion with the workers, some report suffering from neck and back pain. What could be the causes of these problems? (Justify your answer) (5 pts)

Considering the inherent problems of these workstations, you decide to review their design:

   b) Determine the minimum and maximum work seat height to accommodate the women population from 5th to 95th percentiles? The work surface is 4 cm thick. Use the anthropometric data provided in appendix. (5 pts)

   c) Determine the minimum and maximum height of the work surface to accommodate the women population from 5th to 95th percentiles. (5 pts)

   d) Determine the position on the work surface and the distance from the edge of the table of the six trays containing the components to assemble. Draw a sketch of your design. (5 pts)

2) Explain the “oxygen debt” phenomena following a physical effort, insisting on its causes and its effects. (10 pts)

3) What are the important considerations to ensure comfort for a worker assigned to a standing or a sit/stand workstation? (10 pts)

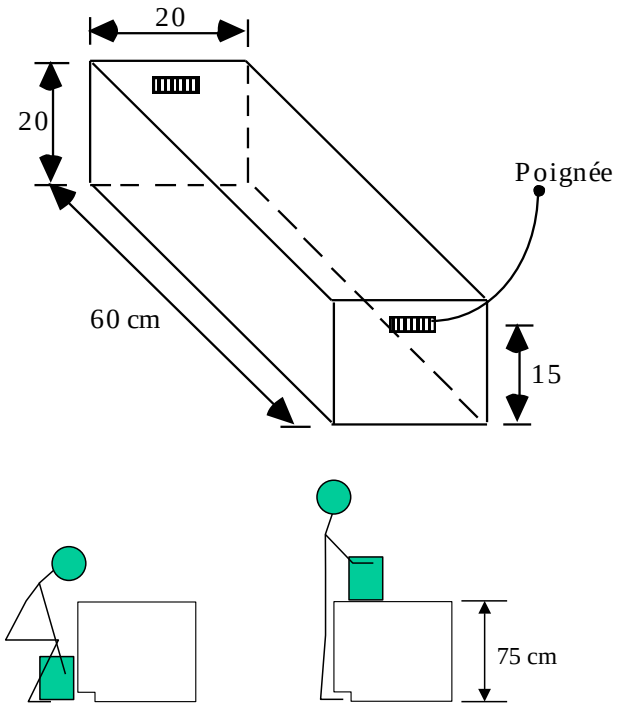
4) True of False? (10 pts)

	True	False
a) The anaerobic metabolism allows recycling of ADP in ATP with oxygen contribution.		
b) For an individual, his oxygen uptake when carrying out a task is function of his maximum aerobic capacity.		
c) The choice of a method of work does not have a significant effect on the heart rate. It only affects the energy expenditure.		
d) According to NIOSH, compressive forces lower than 3400 N on L5/S1 disc are acceptable for 75% of women and 99% of men.		
e) During a long sustained effort, the anaerobic metabolism can be reactivated in order to supply the energy required by the muscles.		
f) Creatine phosphate allows the production of energy required by the muscles for short duration efforts.		
g) The aerobic metabolism inevitably produces an oxygen debt.		
h) When the reflectance of the background of the visual field is low, it is recommended to increase the illuminance.		
i) For a given physical task, the energy expenditure of a 70 Kg man is generally higher than for a 70 Kg woman.		
j) With a low control/response ratio, fine adjustments of a control are more difficult.		

5) Briefly explain the carpal tunnel syndrome and how certain work activities can cause this musculoskeletal disorder (MSD). (10 pts)

6) One says that the extend of the risk of developing an MSD is a function of the duration, the intensity and the frequency of exposure to risk factors. What is the meaning of "intensity of a risk factor"? Briefly explain giving some examples. (10 pts)

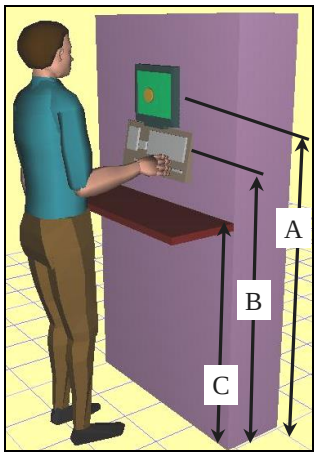
7) Workers must lift boxes containing metal components. These boxes are taken by two handles using the technique shown. They are then laid down on a table (75 cm high). These boxes are lifted 2 or 3 times a day and weigh 28 Kg. Using the NIOSH Manual Lifting Guidelines (equation provided below), determine the RWL for this task. Use a Coupling Multiplier = 1 and a Frequency Multiplier = 1. (10 pts)



RWL (Kg) = 23 (HM) (VM) (DM) (AM) (CM) (FM)

- HM (Horizontal Multiplier) = 25 / H where H = cm
- VM (Vertical Multiplier) = (1 - (0.003 |V -75 |)) where V = cm
- DM (Distance Multiplier) = (0.82 + 4.5 / D) where D = cm
- AM (Asymmetry Multiplier) = (1 - (0. 0032 A)) where A = degrees

8) The figure shows the control station of a CNC machine. Determine the height A of the center of the control screen (fixed height). Describe your design and justify your assumptions. (10 pts)



9) To be in agreement with the eye physiology, luminance level should be used to specify the visual conditions of work environments. However, standards and regulation rather specify the level of illuminance of work surfaces. Briefly explain the reasons for this difference. (10 pts)

Appendix

Anthropometric data

TABLE 1–3. Body Dimensions of U.S. Civilian Adults, Female/Male, in mm

	Percentiles			
	5th	*50th*	*95th*	*SD*
HEIGHTS				
(*f* above floor, *s* above seat)				
Stature ("height")[f]	1,527.8/1,646.9	1,629.4/1,755.8	1,737.3/1,866.5	63.6/66.8
Eye height[f]	1,415.2/1,528.2	1,516.1/1,633.9	1,621.3/1,742.9	62.5/65.7
Shoulder (acromial) height[f]	1,240.9/1,341.6	1,333.6/1,442.5	1,432.0/1,545.6	57.9/62.0
Elbow height[f]	926.3/995.2	997.9/1,072.5	1,074.0/1,152.8	44.8/48.1
Wrist height[f]	727.9/777.9	790.3/846.5	855.1/915.2	38.6/41.5
Crotch height[f]	700.2/764.4	771.4/837.2	845.8/916.4	44.1/46.2
Height (sitting)[s]	795.3/854.5	852.0/913.9	910.2/971.9	34.9/35.6
Eye height (sitting)[s]	684.6/735.0	738.7/792.0	794.3/848.0	33.2/34.2
Shoulder (acromial) height (sitting)[s]	509.1/548.5	555.5/597.8	603.6/646.3	28.6/29.6
Elbow height (sitting)[s]	175.7/184.1	220.5/230.6	264.4/273.7	26.8/27.2
Thigh height (sitting)[s]	140.4/148.6	158.9/168.2	180.2/189.9	12.1/12.6
Knee height (sitting)[f]	474.0/514.4	515.4/558.8	560.2/605.7	26.3/27.9
Popliteal height (sitting)[f]	351.3/394.6	389.4/434.1	429.4/476.3	23.7/24.9
DEPTHS				
Forward reach (to tip of thumb)	676.7/739.2	734.6/800.8	796.7/867.0	36.4/39.2
Buttock–knee distance (sitting)	542.1/569.0	588.9/616.4	639.8/667.4	29.6/29.9
Buttock–popliteal distance (sitting)	440.0/458.1	481.7/500.4	527.7/545.5	26.6/26.6
Elbow–fingertip distance	406.2/447.9	442.9/484.0	482.5/524.2	23.4/23.3
Chest depth	208.6/209.6	239.4/243.2	277.8/280.4	21.1/21.5
BREADTHS				
Forearm–forearm breadth	414.7/477.4	468.5/546.1	528.4/620.6	34.7/43.6
Hip breadth (sitting)	342.5/328.7	384.5/366.8	432.2/411.6	27.2/25.2
HEAD DIMENSIONS				
Head circumference	522.5/542.7	546.2/567.7	570.5/593.5	14.6/15.4
Head breadth	136.6/143.1	144.4/151.7	152.7/160.8	4.9/5.4
Interpupillary breadth	56.6/58.8	62.3/64.7	68.5/71.0	3.6/3.7
FOOT DIMENSIONS				
Foot length	224.4/248.8	244.4/269.7	264.6/292.0	12.2/13.1
Foot breadth	81.6/92.3	89.7/100.6	97.8/109.5	4.9/5.3
Lateral malleolus height[f]	52.3/58.4	60.6/67.1	69.7/76.4	5.3/5.5
HAND DIMENSIONS				
Circumference, metacarpal	172.5/198.5	186.2/213.8	200.3/230.3	8.5/9.7
Hand length	165.0/178.7	180.5/193.8	196.9/210.6	9.7/9.8
Hand breadth, metacarpal	73.4/83.6	79.4/90.4	85.6/97.6	3.8/4.2
Thumb breadth, interphalangeal	18.6/21.9	20.7/24.1	22.9/26.5	1.3/1.4
WEIGHT (in kg)	39.2*/57.7*	62.0/78.5	84.8*/99.3*	13.8*/12.6*

*Estimated (from Kroemer 1981).

Source: Adapted from U.S. Army data reported by Gordon et al. (1989).

Note: In this table, the entries in the 50th-percentile column are actually mean (average) values. The 5th- and 95th-percentile values are from measured, not calculated, data (except for weight). Thus, the values given may be slightly different from those obtained by subtracting 1.65 SD from the mean (50th percentile) or by adding 1.65 SD to it.

Normal distribution table

[z = (x – mean) / standard-deviation]

p	z	p	z	p	z	p	z
1	*-2.33*	*26*	*-0.64*	*51*	*0.03*	*76*	*0.71*
2	*-2.05*	*27*	*-0.61*	*52*	*0.05*	*77*	*0.74*
3	*-1.88*	*28*	*-0.58*	*53*	*0.08*	*78*	*0.77*
4	*-1.75*	*29*	*-0.55*	*54*	*0.10*	*79*	*0.81*
5	*-1.64*	*30*	*-0.52*	*55*	*0.13*	*80*	*0.84*
6	*-1.55*	*31*	*-0.50*	*56*	*0.15*	*81*	*0.88*
7	*-1.48*	*32*	*-0.47*	*57*	*0.18*	*82*	*0.92*
8	*-1.41*	*33*	*-0.44*	*58*	*0.20*	*83*	*0.95*
9	*-1.34*	*34*	*-0.41*	*59*	*0.23*	*84*	*0.99*
10	*-1.28*	*35*	*-0.39*	*60*	*0.25*	*85*	*1.04*
11	*-1.23*	*36*	*-0.36*	*61*	*0.28*	*86*	*1.08*
12	*-1.18*	*37*	*-0.33*	*62*	*0.31*	*87*	*1.13*
13	*-1.13*	*38*	*-0.31*	*63*	*0.33*	*88*	*1.18*
14	*-1.08*	*39*	*-0.28*	*64*	*0.36*	*89*	*1.23*
15	*-1.04*	*40*	*-0.25*	*65*	*0.39*	*90*	*1.28*
16	*-0.99*	*41*	*-0.23*	*66*	*0.41*	*91*	*1.34*
17	*-0.95*	*42*	*-0.20*	*67*	*0.44*	*92*	*1.41*
18	*-0.92*	*43*	*-0.18*	*68*	*0.47*	*93*	*1.48*
19	*-0.88*	*44*	*-0.15*	*69*	*0.50*	*94*	*1.55*
20	*-0.84*	*45*	*-0.13*	*70*	*0.52*	*95*	*1.64*
21	*-0.81*	*46*	*-0.10*	*71*	*0.55*	*96*	*1.75*
22	*-0.77*	*47*	*-0.08*	*72*	*0.58*	*97*	*1.88*
23	*-0.74*	*48*	*-0.05*	*73*	*0.61*	*98*	*2.05*
24	*-0.71*	*49*	*-0.03*	*74*	*0.64*	*99*	*2.33*
25	*-0.67*	*50*	*0*	*75*	*0.67*		