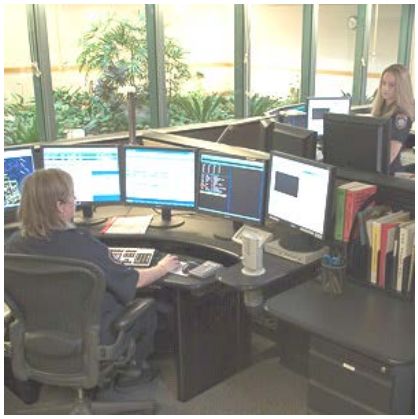
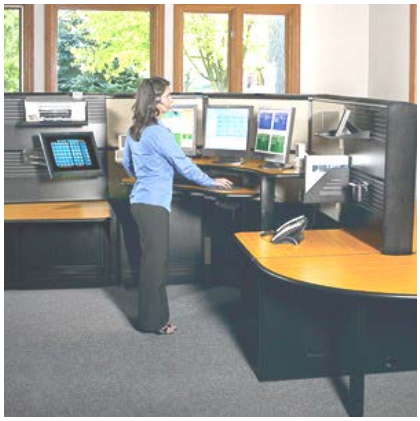
ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2018 SESSION

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

14-IN-B2 Ergonomics

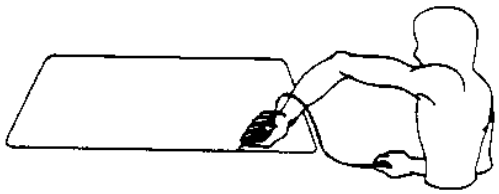
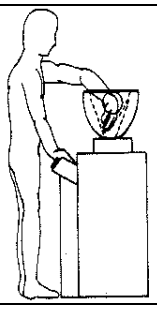
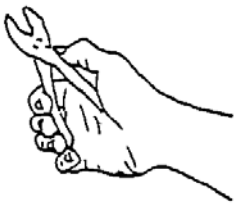
1) In a 911 call center, dispatchers usually work in a sitting posture, but may prefer to stand during short periods of stressful situations.

Considering normal work clothing, determine the values to accommodate 99% of industrial workers (males and females) for the following elements (justify your answers with calculus **using the anthropometric data provided in appendix**) (20 pts):

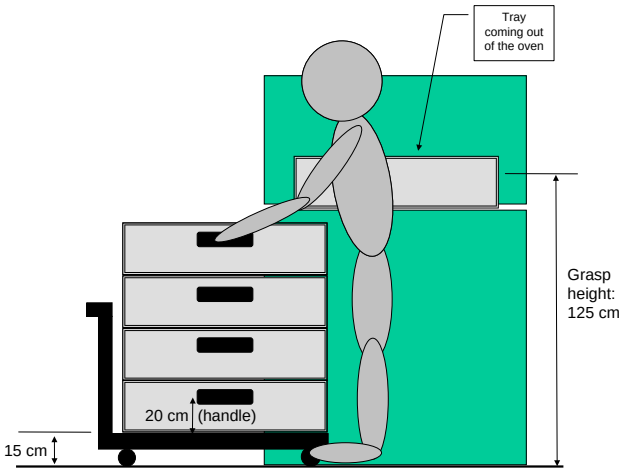
a) Minimum and maximum height of an adjustable work seat.
b) Minimum and maximum height of the adjustable worktable on which rest the mouse and keyboard.
c) Minimum and maximum height of the adjustable stand on which rest the monitors, considering that the center of monitor screen is 29 cm from its base (vertical dimension), and that they are positioned at an average reading distance is 65 cm from the dispatchers' eyes.

2) What are the bad postures and the other conditions which make the tasks illustrated below not recommendable (be specific)? (10 pts)

		
A	B	C

3) A worker must remove pastry trays from an industrial baking oven. She takes the trays coming out of the oven and places them on a cart, which will be taken by another worker. Each cart contains 5 trays, piled up one on top of the other. As she lifts the trays from the oven, the worker makes a 45° trunk rotation. The hot pastries are relatively fragile and they must be handled carefully. Using the NIOSH 1994 Manual Lifting Guidelines (equation provided below), determine if this work is acceptable for 75% of women and 99% of men. (15 pts)

- Grasp height of the trays coming out of the oven (hand height) : 125 cm
- Tray size : 75 cm x 75 cm x 25 cm high
- Work pace : 3 trays per minute
- Weight of a full tray : 5 Kg
- Work duration: 8 hours

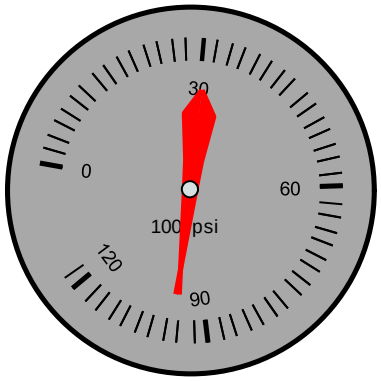


RWL (Kg) = 23 (HM) (VM) (DM) (AM) (CM) (FM)

- 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

Note: Use a Coupling Multiplier CM = 1 and a Frequency Multiplier FM = 0.8.

4) The reading accuracy required for this pressure gauge is 50 PSI. It must be readable at a distance of 2 meters in a relatively dim environment. The height of the characters (numbers) is 4.5 mm. The usual pressure reading is around 9000 PSI. From an ergonomics point of view, which are the inherent design problems with this pressure gauge? (10 pts)



5) Discuss the different options that can be used to facilitate the identification of manual controls. (10 pts)

6) Explain the reasons why cold temperatures are considered as a risk factor in the development of work related musculoskeletal disorders. (10 pts)

7) List and discuss the different ergonomic risk factors for low-back pain. (10 pts).

8) A 35 years old male worker with an average fitness level and weighing 75 Kg carries out a task using the whole body, for which the average energy expenditure is estimated at 5.13 Kcal/min. This task is carried out for an 8 hours shift, including a 15 minutes break during morning, a 30 minutes break at lunchtime and a 15 minutes break during the afternoon. The energy expenditure of this worker during the rest periods is 1.25 Kcal/min. Is this task acceptable? Justify your answer with calculus. (15 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*		