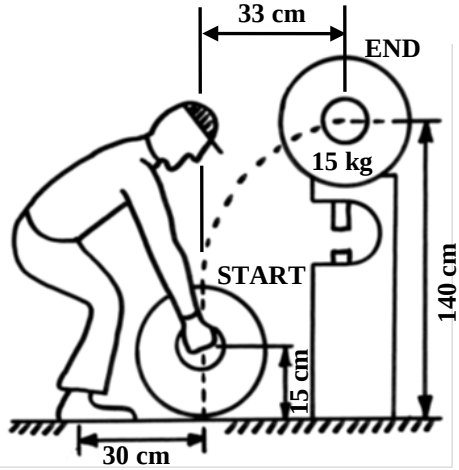
Consider the following MMH case study then answer the questions to follow.

Examine the figure on the right. Note the following:



- one lift is performed every 4 hours (shift of 8 hours)
- there is a firm grasp on the water bottle
- feet remain fixed in place, and no twisting is involved
- **hint**: consider *the more dangerous* horizontal distance

A. Determine components and multipliers of the lifting task (use the table below) **[2 points]**

	Component Value	**Multiplier Value**
H		
V		
D		
F		
A		
C		

B. What is the Recommended Weight Limit for the task? **[1 pt]**

C. Is the lifting task considered safe or dangerous? **[1 pt]**

Explain below.

D. If you answered “dangerous”, what is the critical factor? **[1 pt]**

E. If you answered “dangerous”, you are now asked to redesign the lifting process by showing how you would account for the critical factor you mentioned above. You must:

   a. Sketch the design of the new lifting process **[3 pt]**
   b. Show steps and calculations to determine the new RWL value **[1 pt]**
   c. Show whether the modified process is now safe or dangerous **[1 pt]**

Note, if “dangerous” you should repeat the process until it is safe.

Consider the following MMH case study then answer the questions to follow.

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- one lift is performed every 4 hours (shift of 8 hours)
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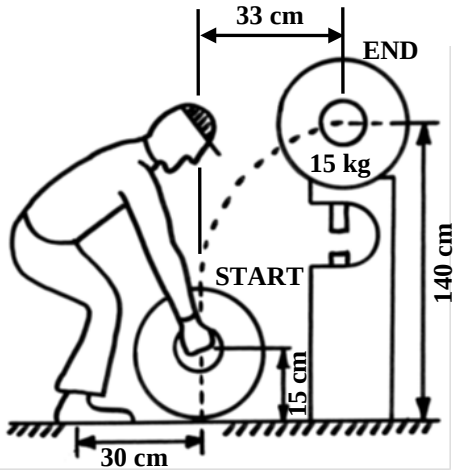


F. Determine the components and multipliers of the lifting points]

	Component Value	Multiplier Value
H	**63 cm**	$\frac{25}{H} = \frac{25}{63} = 0.397$
V	**15 cm**	$VM = 1 - (0.003\|V - 75\|)$ $= 1 - 0.003\|15 - 75\| = 0.82$
D	**125 cm**	$DM = 0.82 + \left(\frac{4.5}{D}\right) = 0.82 + \frac{4.5}{125} = 0.856$
F	$4 * 60 = 240\ min$	**0.85 (directly from FM table @ 8hr; stooping)**
A	**0°**	$AM = 1 - (0.0032A) = 1 - 0 = 1$
C	**good**	**1 (directly from CM table; stooping)**

G. What is the Recommended Weight Limit for the task? [1 pt]

$5.45\ kg$

$RWL = 23\ kg * [0.397 * 0.82 * 0.856 * 0.85 * 1 * 1]$

$= 23 * 0.2369 = 5.45\ kg$

H. Is the lifting task considered safe or dangerous? [1 pt]

dangerous

Explain below.

weight of load (15 kg) $>$ RWL (5.45 kg)

I. If you answered “dangerous”, what is the critical factor? [1 pt]

HM

the critical factor is most likely HM, the horizontal distance (H) of the water bottle from worker's body (since it has the smallest multiplier value, HM)

J. If you answered “dangerous”, you are now asked to redesign the lifting process by showing how you would account for the critical factor you mentioned above. You must:
   a. Sketch the design of the new lifting process [3 pt]
   b. Show steps and calculations to determine the new RWL value [1 pt]
   c. Show whether the modified process is now safe or dangerous [1 pt]

Note, if “dangerous” you should repeat the process until it is safe.

a) Note, assuming we will only redesign ***H*** (i.e. no change in any other multiplier), the min. ***HM*** such that:

$$W \leq RWL \leq LC * HM * VM * DM * FM * 1 * 1 \Rightarrow$$

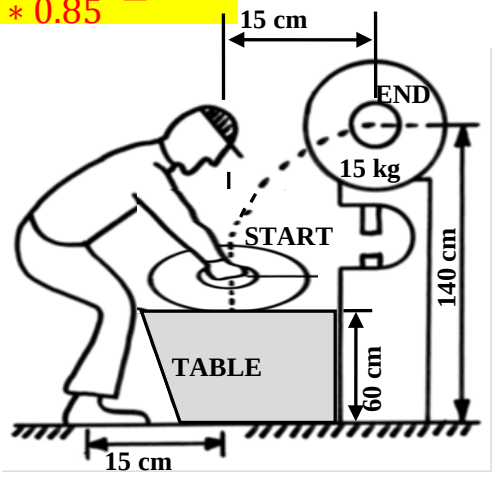
$$HM \geq \frac{W}{LC * VM * DM * FM} \geq \frac{15}{23 * 0.82 * 0.856 * 0.85} \geq 1.09$$

(which is not possible);

i.e. **it is not possible to rely on changing *H* alone**

In any case (as shown on the right),

we bring the water bottle closer to the device



(i.e. shortening the H from 63 to the minimum 30 cm)

$\Rightarrow$ new $\boldsymbol{HM = \frac{25}{H} = \frac{25}{30} = 0.833}$

Other important factors are **VM** and **HM** (since both are closely related)

We redesign (as shown on the right) by placing a table such that

$$VM * DM \geq \frac{W}{LC * HM * FM} \geq \frac{15}{23 * \mathbf{0.833} * 0.85} \geq 0.921$$

i.e. it is possible to redesign by relying on changing only HM, VM and DM

As shown, in order to maximize VM, a table is chosen with 60 cm height

$\Rightarrow$

$$VM = 60 + 15 = 75\ cm \Rightarrow \boldsymbol{VM = 1 - (0.003|75 - 75|) = 1}$$

$$DM = 140 - 75 = 65 \Rightarrow \boldsymbol{DM = 0.82 + \left(\frac{4.5}{65}\right) = 0.889}$$

However, note how $VM * DM$ is still $<$ the minimum (0.921) value

The last factor that we can redesign is FM, which must be such that:

$$FM \geq \frac{W}{LC * HM * VM * DM} \geq \frac{15}{23 * \mathbf{0.833} * \mathbf{1} * \mathbf{0.889}} \geq 0.88$$

by using the FM table, we conclude that we need to boost FM from 0.85 to the next higher value of 0.95, at

$F = 5\ min\ @\ 2\ hours, standing\ (since\ V = 75\ cm)$, i.e. it is possible to perform only 1 lift

In summary, to make the process safe, the task was redesigned as follows:

	Component Value	**Multiplier Value**

H	$\mathbf{30\ cm}$	$\mathbf{HM = 0.833}$
V	$\mathbf{75\ cm}$	$\mathbf{VM = 1}$
D	$\mathbf{65\ cm}$	$\mathbf{DM = 0.889}$
F	$\mathbf{2 * 60 = 120\ min}$	$\mathbf{FM = 0.95}$
A	$\mathbf{0°}$	$\mathbf{AM = 1}$
C	**good**	**1 (directly from CM table; stooping)**

b) Assessing the six components in the redesigned task:

$$RWL = 23\ kg * [0.833 * 1 * 0.889 * 0.95 * 1 * 1]$$

$$\Rightarrow \mathbf{RWL = 16.1\ kg}$$

c) weight of load (15 kg) $<$ RWL (16.1 kg)

$\Rightarrow$ **most workers can perform the task safely**

H = Horizontal Distance (cm)	HM Factor
25 or less	1.00
30	0.83
40	0.63
50	0.50
60	0.42
63	0.40
>63	0

V = Starting Height (cm)	VM Factor
0	0.78
30	0.87
50	0.93
70	0.99
80	0.99
100	0.93
150	0.78
175	0.70
>175	0

A = Angle (°)	AM Factor
0	1.00
30	0.90
45	0.86
60	0.81
90	0.71
105	0.66
120	0.62
135	0.57
>135	0

D = Lifting Distance (cm)	DM Factor
25 or less	1.00
40	0.93
55	0.90
100	0.87
145	0.85
175	0.85
>175	0

C = Grasp	CM Factor:	
	Standing	Stooping
Good (handles)	1.00	1.00
Fair	1.00	0.95
Poor	0.90	0.90

F=Time Between Lifts	FM Factor					
	Lifting While Standing (V ≥ 75 cm)			Lifting While Stooping (V < 75 cm)		
	≤ 1 hr.	>1 & ≤ 2 hr.	>2 & ≤ 8 hr.	≤ 1 hr.	>1 & ≤ 2 hr.	>2 & ≤ 8 hr.
≥5 min	1.00	0.95	0.85	1.00	0.95	0.85
2 min	0.97	0.92	0.81	0.97	0.92	0.81
1 min	0.94	0.88	0.75	0.94	0.88	0.75
30 sec	0.91	0.84	0.65	0.91	0.84	0.65
15 sec	0.84	0.72	0.45	0.84	0.72	0.45
10 sec	0.75	0.50	0.27	0.75	0.50	0.27
6 sec	0.45	0.26	0.13	0.45	0.26	0
5 sec	0.37	0.21	0	0.37	0	0

- Alternative formulae for multipliers:
  - $HM = [25/H]$ {note, 25 ≤ H [cm] ≤ 63 cm}
  - $VM = [1 - (0.003|V - 75|)]$ {note, 0 ≤ V [cm] ≤ 175 cm}
  - $DM = [0.82 + (4.5/D)]$ {note, 25 ≤ D [cm] ≤175 cm}
  - $AM = [1 - (0.0032A)]$ {note, 0° ≤ A ≤135°}