17 1

SCHEME OF VALUATION (B)

(Scoring Indicators)

Revision : 2015			**Course Code: 5021**	
Course Title : Design of Machine Elements				
Qst. No.	**Scoring Indicator**	**Split up score**	**Sub Total**	**Total**
	PART. A			
I. 1.	It is the distance moved by the threaded part parallel to the screw axis in one complete rotation.	2		2
I. 2.	It is defined as the ratio between the ideal effort to the actual effort.	2		2
I. 3.	i. to connect shafts ii. To provide mis alignment. Iii. To alter vibration. iv. To transmit power.	1	1x2	2
I. 4.	The function of flywheel is to act as reservoir of energy in a machine.	2		2
I. 5.	The relative motion between the pulleys and the belt is called slip of belt.	2		2
II.1.	PART B i. Convenient to asemble and disassemble. Ii. Highly reliable joints in operation. Iii. Can be placed in any positon. iv. Compact construction. v. May be adopted to various operating conditions. vi. Economical to manufacture.	1	1 x 6	6
II.2.	No. of screws n = 2 Tensile load P = 10 kN = 10 x 10^3 N Working stress = 45 MPa $P = \frac{\pi}{4} d_c^2 \sigma_t \cdot n$ Core dia. of bolt $d_c = \sqrt{\frac{4P}{\pi \sigma_t n}} = \sqrt{\frac{4\times10^4}{\pi\times45\times2}}$ $= 11.89$ mm. Nominal dia. of bolt $d = \frac{d_c}{0.84}$ $= \frac{11.89}{0.84} = 14.16$ mm		2+2+2	6

Std size = 16 mm.

II.3.	T = Twisting moment or torque N-mm J = Polar moment of inertia mm^4 t = Torsional shear stress MPa r = Radius of shaft mm From torsion equation $\frac{T}{J} = \frac{\tau}{r}$ $T = \frac{\tau}{r} . J$ $J = \frac{\pi d^4}{32}$, d = dia of shaft. $T = \frac{\tau}{d/2} . \frac{\pi d^4}{32}$, $r = d/2$ $T = \frac{\pi}{16} \tau d^3$	6		6
II.4.	1. According to the shape of the surface in contact. i. Kinfe edge follower ii. Roller follower iii. Flat face or mushroom ended follower. iv. Spherical face follower. 2. According to the motion of the follower. i Reciprocating or translating follower. ii. Oscillating follower 3. According to the location of line of movement of the follower. i. Radial follower ii. Offset follower.	2 2 2	2+2+2	6
II.5.	Flywheel / Governor 1. Stores and distributes energy / 1. Contriols the amount of fuel 2.Takes care of fluctuations of speed. / 2.Takes care of speed on load 3.Works continuously. / 3. Works intermittenly. 4.No control over quantity and quality of working agent. / 4. Takes care of quantity and of working agent. 5.Is not an essential element of every prime mover. / 5.Is an essential element of every prime mover. 6.Used only in case when undesirable cyclic fluctuation of energy. / 6.It is an adjuster of supply of fuel with demand.	1	6 x 1	6

II.6.	Velocity ratio gives a relation between the speed of driven and driver. It is defined as the ratio of speed of driven pulley to that of the driving pulley. Due to the slip between the belt and pulley, the VR of drive is not exact. N1 = Rotational speed of driving pullley in rpm. N2 = Rotational speed of driven pullley in rpm. d1 = Diameter of driving pulley in mm. d2 = Diameter of driven pulley in mm. Surface speed of driving pulley v1 = π d1 N1 Surface speed of driving pulley v2 = π d2 N2 Assume no slip v1 = v2 or π d1 N1 = π d2 N2 d1 N1 = d2 N2 V.R = N2/N1 = d1/d2 VR = Speed of follower/Speed of driver If thickness of belt considered VR = N2/N1 = d1+t/d2+t	6		6
II.7.	1.Give positive drive and constant speed without slip. 2.More compact 3.Can be operated at higher speeds 4.High efficiency 5.Lighter loads on shafts and bearings 6.Used where precise timing is desired 7.Wide range of power transmitted. 8.Less maintenance. 9.Can be used for non intersecting and non parallel shafts	1	1x6	6

4

III. a. dia. of screw $d = 40\ mm$

pitch $p = 8.5\ mm$

$\mu = 0.15$

Tension force $W = 8000\ N$

Mean diameter $d_m = d - 0.5p$

$= 40 - 0.5 \times 8.5$

$= \underline{35.75\ mm}$ 1

Helix angle $\alpha = \tan^{-1}\left(\frac{np}{\pi d_m}\right)$

$= \tan^{-1}\left(\frac{1 \times 8.5}{\pi \times 35.75}\right) = \underline{4.33^\circ}$ 1½

Friction angle $\phi = \tan^{-1}\mu$

$= \tan^{-1} 0.15 = \underline{8.53^\circ}$ 1½

9

Torque required to overcome friction

$T = W \tan(\alpha + \phi) \frac{d_m}{2}$

$= 8000 \tan(4.33 + 8.53) \times \frac{35.75}{2}$

$= 32646.32\ N\text{-}mm$

$= \underline{32.65\ N\text{-}m}$ 3

Total torque required to tighten both ends of the rods

$T = 2 \times 32.65 = \underline{65.3\ N\text{-}m}$ 2

III.b.	Diameter of shaft $d = 40\,mm$ Tangential force $F = 20\,kN$ $= 20 \times 10^3\,N$ Stress $\tau = 60\,MPa$ $= 60\,N/mm^2$ Width of key $w = d/4 = \frac{40}{4} = \underline{10\,mm}$ Thickness $t = d/6 = \frac{40}{6} = 6.67\,mm$ $\approx \underline{7\,mm}.$ $F = l.w.\tau$ Length of key $l = \frac{F}{w\tau}$ $= \frac{20 \times 10^3}{10 \times 60}$ $= 33.33\,mm$ $= \underline{34\,mm}$. Size of key $= \underline{10 \times 7 \times 34}$.	 1 1 4		6
IV. a	Steam pressure $P_s = 1.2\,MPa$ Back pressure $P_b = 0.015\,MPa$ Cylinder dia: $D = 300\,mm$ Tensile stress $\sigma_t = 45\,MPa$. Effective steam pressure $P = P_s - P_b$ $= 1.2 - 0.015$ $= \underline{1.185\,MPa}$	 1		

IV.a.	Force on piston rod $P = \frac{\pi D^2}{4} \cdot p$ $= \frac{\pi}{4} \times 300^2 \times 1.185$ $= 83720.25 \ N$ Resistance by screwed end $P = \frac{\pi d_c^2}{4} \sigma_t$ Core dia. of screwed end $d_c = \sqrt{\frac{4P}{\pi \cdot \sigma_t}} = \sqrt{\frac{4 \times 83720.25}{\pi \times 45}}$ $= 48.68 \ mm$ Nominal diameter $d = \frac{d_c}{0.84}$ $= \frac{48.68}{0.84}$ $= 57.95 \ mm.$ $= 58 \ mm$	3 4 2		9

IV.b.	Dia: of shaft $d = 40\ mm$ Width of key $w = 12\ mm$ Thickness $t = 8\ mm$ length $l = 65\ mm$ Torque $T = 750\ N\text{-}m$ $= 750 \times 10^3\ N\text{-}mm$ $\tau = 60\ MPa$ $\sigma_c = 150\ MPa$ Consider shearing, $T = l \cdot w \cdot \tau \cdot \frac{d}{2}$ $\tau = \frac{2 \cdot T}{l \cdot w \cdot d} = \frac{2 \times 750 \times 10^3}{65 \times 12 \times 40}$ $= 48.08\ N/mm^2$ Consider crushing, $T = l \cdot \frac{t}{2} \cdot \sigma_c \cdot \frac{d}{2}$ $\sigma_c = \frac{4 \cdot T}{l \times t \times d}$	3		6
	$= \frac{4 \times 750 \times 10^3}{65 \times 8 \times 40}$ $= 144.23\ N/mm^2$ Induced stresses are less than permissible stress hence the length is sufficient.	3		

6

V.a.

$P = 100\ kW = 100 \times 10^3\ W$

$N = 200$ rpm.

Shaft $\tau_s = 50$ MPa.

key $\tau_k = 50$ MPa

" $\sigma_c = 100$ MPa

muff $\tau_m = 15$ MPa

$T_{max} = T_{mean}$

Design of shaft.

$$T_{mean} = \frac{60P}{2\pi N} = \frac{60 \times 100 \times 10^3}{2\pi \times 200}$$

$$= 4774.65\ N\text{-}m$$

$$= \underline{\underline{4774.65 \times 10^3\ N\text{-}mm}}$$

Dia: of shaft $d = \sqrt[3]{\frac{16T}{\pi \tau_s}}$

[redacted].

$$= \sqrt[3]{\frac{16 \times 4774.65 \times 10^3}{\pi \times 50}}$$

$$= 78.64\ mm$$

Std. size $d = \underline{\underline{80\ mm}}$

3

Design of sleeve

Inside dia: $d = 80$ mm.

Outside dia. $D = 2d + 13$ mm

$= 2 \times 80 + 13$

$= \underline{\underline{173\ mm}}$

Length $L = 3.5d$

$= 3.5 \times 80 = 280$ mm.

checking the shear stress

$$T = \frac{\pi}{16} \tau_m D^3 (1-k^4)$$

$$\tau_m = \frac{16T}{\pi D^3 (1-k^4)}$$

$$= \frac{16 \times 4774.65 \times 10^3}{\pi \times 173^3 \left[1-\left(\frac{80}{173}\right)^4\right]}$$ 3

$$= \underline{\underline{4.92 \ N/mm^2}} < \text{permissible value.}$$

Design of key, $\sigma_c = 2\tau$ ∴ select square key 9

$$w = d/4 = \frac{80}{4} = 20 \text{ mm}$$

$$t = d/4 = \frac{80}{4} = 20 \text{ mm}$$

$$l = \frac{L}{2} = \frac{280}{2} = 140 \text{ mm}$$

checking the stresses

$$T = l \cdot w \cdot \tau_k \, d/2$$ 3

$$\tau_k = \frac{2T}{l \cdot w \cdot d} = \frac{2 \times 4774.65 \times 10^3}{140 \times 20 \times 80}$$

$$= \underline{\underline{42.63 \ N/mm^2}}$$

$$T = l \cdot t/2 \cdot \sigma_c \cdot d/2$$

$$\sigma_c = \frac{4T}{l \cdot t \cdot d} = \frac{4 \times 4774.65 \times 10^3}{140 \times 20 \times 80}$$

$$= \underline{\underline{85.26 \ N/mm^2}}$$

Induced stresses are less than permissible value hence design is safe.

V. b.

T = Twisting moment or torque, N-mm

J = Polar moment of inertia, mm^4

τ = Maximum shear stress, MPa

r = radius of shaft, mm

From Torsion equation

$$\frac{T}{J} = \frac{\tau}{r}.$$

$$T = \frac{\tau}{r} \cdot J$$

$$J = \frac{\pi}{32}\left(d_o^4 - d_i^4\right)$$

$$= \frac{\pi}{32} d_o^4 \left[1 - \left(\frac{d_i}{d_o}\right)^4\right]$$

$$= \frac{\pi}{32} d_o^4 \left(1 - k^4\right)$$

$$\therefore \quad T = \frac{\tau}{d_o/2} \, \frac{\pi}{32} d_o^4 \left(1 - k^4\right), \quad r = d_o/2$$

$$T = \frac{\pi}{16} \tau \, d_o^3 \left(1 - k^4\right)$$

6

6

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VI. a.

$$T_{max} = 250\ N\text{-}m = 250 \times 10^3\ N\text{-}mm$$

$$n = 4$$

$$\tau_s = \tau_k = 50\ MPa.$$

$$\sigma_c = 100\ MPa.$$

$$\tau_h = 16\ MPa.$$

Design of shaft., $T_{max} = \frac{\pi}{16} \tau_s d^3$

$$d = \sqrt[3]{\frac{16 T_{max}}{\pi \tau_s}} = \sqrt[3]{\frac{16 \times 250 \times 10^3}{\pi \times 50}}$$ 3

$$= 29.42\ mm$$

std size, $d = 30mm$. 9

Design of hub

Inside dia $d = 30mm$

outside dia $D = 2d = 60mm$

Length $L = 1.5d = 45mm$ 3

check the stress, $\tau_h = \frac{16 T_{max}}{\pi D^3 (1-k^4)}$ $k = \frac{d}{D} = \frac{30}{60} = 0.5$

$$= \frac{16 \times 250 \times 10^3}{\pi \times 60^3 \times (1-0.5^4)}$$

$= 6.29\ N/mm^2 <$ permissible value.

Design of key, $\sigma_c = 2\tau$, so select square key

$$w = t = d/4 = \frac{30}{4} = 7.5mm.$$

Length $l = L = 45mm.$ 3

checking shearing and crushing stresses.

VI. b.

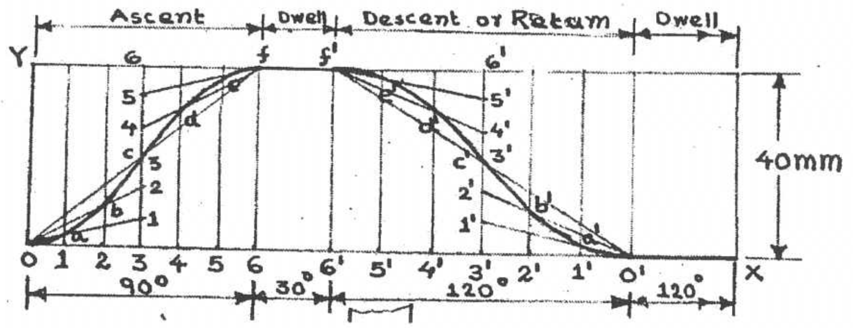
— It should be capable of transmit torque

— It should be permit easy connection and disconnection of shafts. 1½ | 1½×4 | 6

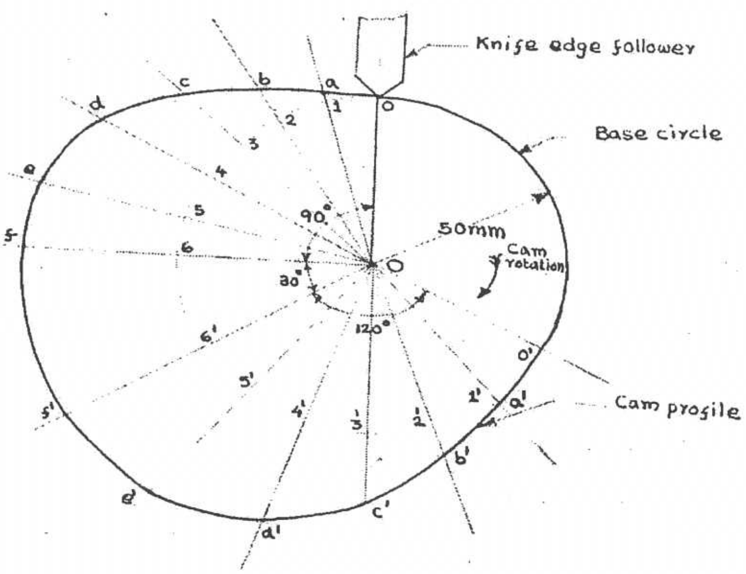
— It should keep the perfect alignment of two shafts.

— It should be safe from projecting parts.

VII. a.



(a) Displacement diagram



(b) Cam profile

3

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VII. b.

No. of collar $n = 1$, $W = 50\ kN = 50 \times 10^3\ N$

Inner dia. of collar $d_1 = 250\ mm$

Outer dia. " $d_2 = 400\ mm$

$\mu = 0.02$

$N = 120\ rpm$

Mean radius of collar $R = \frac{2}{3}\left[\frac{r_2^3 - r_1^3}{r_2^2 - r_1^2}\right]$

$= \frac{2}{3}\left[\frac{200^3 - 125^3}{200^2 - 125^2}\right]$ 2

$= \underline{165.38\ mm}$

6

$T = \mu W R = 0.02 \times 50 \times 10^3 \times 165.38$

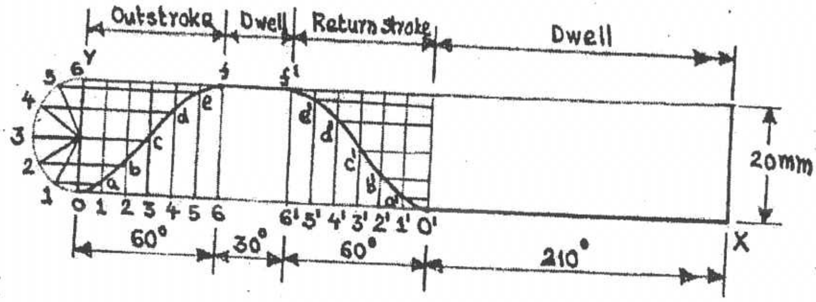
$= 165380\ N\text{-}mm$

$= \underline{165.38\ N\text{-}m}$ 2

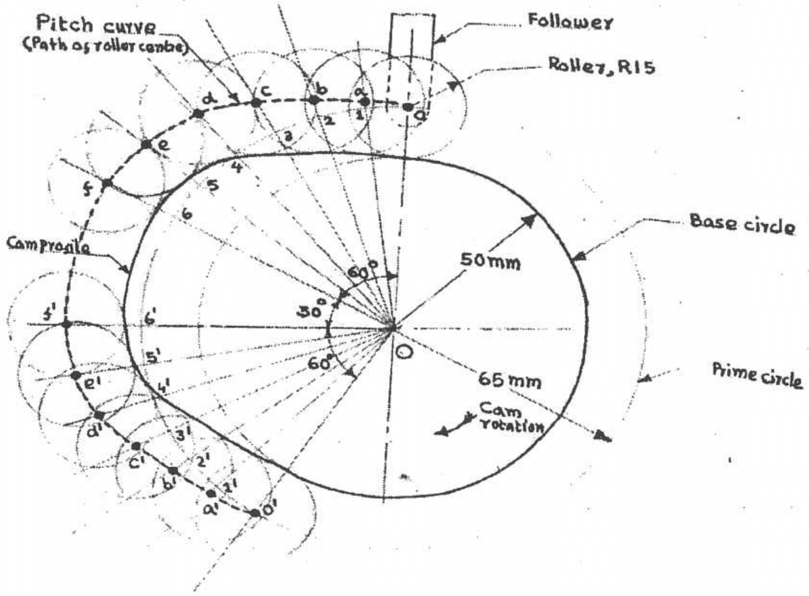
Power lost $P = \frac{2\pi N T}{60} = \frac{2\pi \times 120 \times 165.38}{60}$

$= \underline{2078.23\ W}$ 2

VIII. a.



(a) Displacement diagram



(b) Cam profile

13

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9

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VIII. b

Dia. of journal $d = 200\,mm$
$= 200 \times 10^{-3}\,m$

Load $W = 50\,kN = 50 \times 10^{3}\,N$

$N = 100\,rpm.$

$\mu = 0.02$

Rubbing velocity $v = \frac{\pi d N}{60}$

$= \frac{\pi \times 200 \times 10^{-3} \times 100}{60}$

$= \underline{\underline{1.05}}\ m/s$ 3

Heat generated $Q_g = \mu W v$

$= 0.02 \times 50 \times 10^{3} \times 1.05$

$= \underline{\underline{1050\ W}}$

$= \underline{\underline{1.05}}\ kW$ 3

6

IX.a.	Dia. of larger pulley $d_2 = 450\,mm = 450 \times 10^{-3}\,m$ " smaller " $d_1 = 200\,mm = 200 \times 10^{-3}\,m$ distance b/w pulley $C = 1.95\,m$ Speed of larger pulley $N_2 = 200\,rpm$ Max. tension in belt $T_1 = 1\,kN = 1 \times 10^{3}\,N$ $\mu = 0.25$ Length of cross belt $L = \frac{\pi}{2}(d_2+d_1) + 2C + \frac{(d_2+d_1)^2}{4C}$ $L = \frac{\pi}{2}(450+200) + 2 \times 1.95 \times 10^{3} + \frac{(450+200)^2}{4 \times 1.95 \times 10^{3}}$ $= 4975.18\,mm$ $= \underline{\underline{4.98\,m}}$	3		9
	Angle of lap $\theta = \pi + 2\sin^{-1}\left[\frac{d_2+d_1}{2C}\right]$ $= 180^\circ + 2\sin^{-1}\left[\frac{450+200}{2 \times 1.95 \times 10^{3}}\right]$ $= \underline{\underline{199.19^\circ}}$ $= 199.19 \times \frac{\pi}{180} = \underline{\underline{3.48\,rad}}$	3		
	Power transmitted $P = T_1\left(1 - \frac{1}{e^{\mu\theta}}\right)\frac{\pi d N}{60}$ $= 1 \times 10^{3}\left[1 - \frac{1}{e^{0.25 \times 3.48}}\right]\frac{\pi \times 450 \times 10^{-3} \times 200}{60}$ $= 2738.13\,W$ $= \underline{\underline{2.74\,kW}}$	3		

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<td>IX.b.</td>
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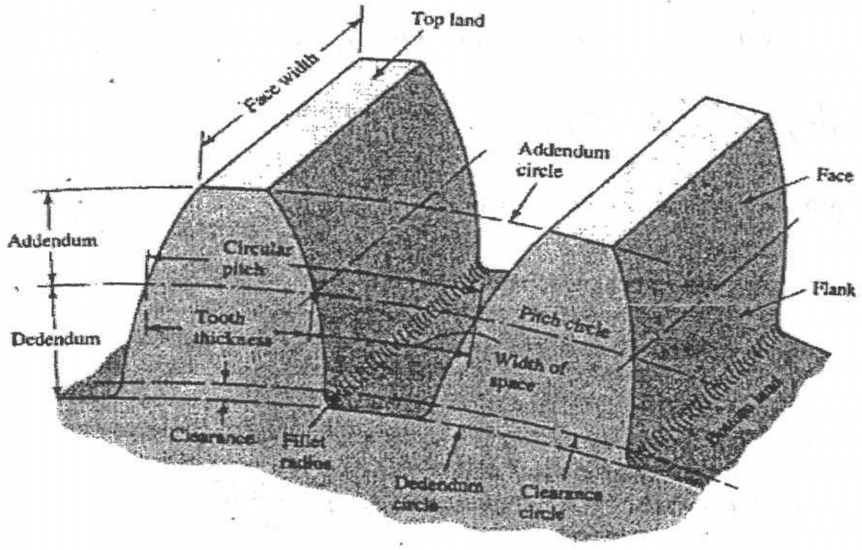

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<tr>
<td>X.a.</td>
<td>
$d_1 = 300$ mm
$N_1 = 200$ rpm
$c = 3\,m = 3\times10^3$ mm
$N_2 = 120$ rpm
$t = 5$ mm
slip S_1 & $S_2 = 3\%$
Total slip $= S = S_1 + S_2$
$= 3 + 3 = 6\%$
$\frac{N_2}{N_1} = \frac{d_1+t}{d_2+t}\left(1-\frac{S}{100}\right)$
dia. of 2^{nd} pulley $d_2 = \left[(d_1+t)\left(1-\frac{S}{100}\right)\frac{N_1}{N_2}\right] - t$
$d_2 = \left[(300+5)\left(1-\frac{6}{100}\right)\frac{200}{120}\right] - 5$
$= \underline{\underline{472.83\text{ mm}}}$.
Length of belt $L = \frac{\pi}{2}(d_2+d_1) + 2c + \frac{(d_2-d_1)^2}{4c}$
$= \frac{\pi}{2}(472.83 - 300) + 2\times3\times10^3 + \frac{(472.83-300)^2}{4\times3\times10^3}$
$= 7216.45$ mm
$= \underline{7.22\text{ m}}$
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X.b.	1. No slip takes palace hence perfect VR 2. More compact than belt drive 3. It occupies less space 4. It can be used where exact movement is required. 5. No initial tension is required for its operation. 6. It is used with sprokets which are less costly than pulleys. 7. Less load on shafts compared to belt drive. 8. Un affected by temperature. 9. Possible to transmit power or motion to several shafts. 10. it can be employeed both for long or short centere distances. 11. It is more durable.	1	1 x 6	6