PANDIAN SARASWATHI YADAV ENGINEERING COLLEGE

Madurai - Sivagangai Highway, Thirumansolai Post, Arasanoor, Sivagangai - 630 561

Read the instructions given below carefully before filling in the title page
(To be filled in by the candidate)

REGISTER NUMBER	9	1	2	0	2	0	1	1	4	0	0	2

Student Name	R. AKASH		
Degree / Branch	B.E. Mechanical Engineering		
Subject Code	ME8593	Subject Title	Design of Machine Elements

Year / Semester / Sec	III / V / -	All particulars given are verified
Date & Session	27/09/2022 - FN	27/9/22
No. of Pages used		Name and Signature of the Hall Supdt. with date

PART - A		PART - B						GRAND TOTAL (IN WORDS)
Question No.	Marks	Question No.		Marks I	II	III	Total	
1	2	11 (8)	a	10				Eighty six
2	2		b					
3	2	12 (9)	a	12				
4	2		b					
5	2	13 (10)	a	7				
6	2		b					GRAND TOTAL
7	2	14	a	29		43/50		
8			b					86%
9		15	a					
10			b					
Total	14							

28/9/22 Date	Signature of the Examiner	Signature of the HOD

Instructions to the Candidates :

1. Write your Register No. in the type as shown in the following example

6	2	0	1	1	3	7	5	1	0	2	1

2. Write your Register Number at the Top Right Hand Side of the QUESTION PAPER
3. Use both sides of the paper for answering questions.
4. Possession of any incriminating material and malpractice of any nature shall be punishable as per rules.
5. Answers must be legibly written in ink (Blue, Black or Blue Black)
6. Drawings and Sketches should be drawn using pencil.

Factors ~~aff~~ influencing machine design

* Strength and Stiffness
* Surface finish and tolerances
* Manufacturability
* Ergonomics and aesthetics
* Working atmosphere
* Wear and hardness requirement
* Cooling and lubrication
* Safety and reliability
* Noise requirement
* cost

2) Material properties hardness, Stiffness and resilence

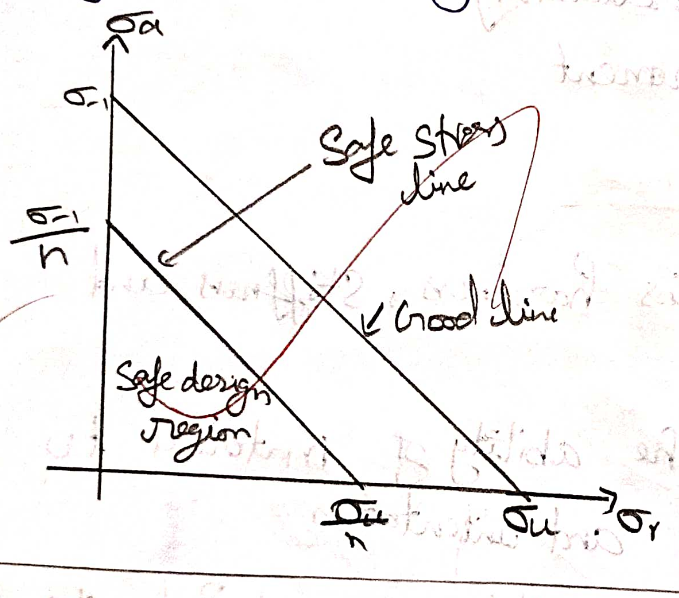
* Hardness is the ability of material to resist Scratching and intentation
* Stiffness is the ability of material to resist deformation under loading.
* Resilence is the ability of material to resist absorb energy and to resist Shock and impact load

3) Stress concentration factor

Stress concentration is the increase in local stresses at points of rapid change in cross section or discontinuities.

* Stress concentration factor K_t is the ratio of maximum stress at critical section to the nominal stress $K_t = \frac{\sigma_{max}}{\sigma_0}$

4) Goodman and Soderberg diagrams and locate the safe design region



5) Function of woodruff key

* A woodruff key is used to transmit less torque in automotive and machine tool industries

* The keyway in the shaft is milled in a curved shape whereas the key way in the hub usually straight.

6) Equivalent bending moment

when a shaft is subjected to combined bending and torsion loading, the design is usually based on the maximum shear stress theory since the shafts are usually made of ductile materials. The expression $\frac{1}{2}(M_b + \sqrt{M_b^2 + M_t^2})$ is called equivalent bending moment and is denoted by M_{be}

Equivalent bending moment $M_{be} = \frac{1}{2}(M_b + \sqrt{M_b^2 + M_t^2})$

diameter of shaft

$$M_{be} = \frac{\pi}{32} \times \sigma_b \times d^3$$

---

7) G.D

$l = 750mm$

$\tau = 40MPa = 40 N/mm^2$

$\theta = 0.017$ radian

$G = 0.8 \times 10^5 MPa = 0.8 \times 10^5 N/m^2$

find: d

Solution:-

$$M_t = \frac{\pi}{16} \times \tau \times d^3$$

$$\theta = \frac{M_t \times l}{GJ} = \frac{\frac{\pi}{16} \times \tau \times d^3 \times l}{G \times \left(\frac{\pi d^4}{32}\right)} = \frac{2\tau l}{Gd}$$

$$0.017 = \frac{2 \times 40 \times 750}{0.8 \times 10^5 \times d}$$

$$\boxed{d = 44.11 \text{ mm}}$$

8 G.D

$d = 200\ mm$

$W_{min} = -50N$

$W_{max} = 150N$

$n = 2$

$K_t = 1.4$

$q = 0.9$

$\sigma_u = 550\ N/mm^2$

$\sigma_y = 320\ N/mm^2$

$\sigma_{-1} = 275\ N/mm^2$

$K_{sz} = 0.85$

$K_{ff} = 0.9$

To find:

d - diameter of rod

Solution:

$M_{bmax} = W_{max} \times d = 150 \times 10^3 \times 200 = 3 \times 10^7\ N\text{-}mm$

$M_{bmin} = W_{min} \times d = -50 \times 10^3 \times 200 = -1 \times 10^7\ N\text{-}mm$

$$Z = \frac{\pi d^3}{32}$$

$$\sigma_{max} = \frac{M_{bmax}}{Z} = \frac{3 \times 10^7}{\frac{\pi d^3}{32}} = \frac{0.056 \times 10^8}{d^3}$$

$$\sigma_{min} = \frac{M_{bmin}}{Z} = \frac{-1 \times 10^7}{\frac{\pi d^3}{32}} = \frac{-1.018 \times 10^8}{d^3}$$

$\sigma_m = \sigma_{max} + \sigma_{min}$

$$= \frac{3.056 \times 10^8}{d^3} + \left(\frac{-1.018 \times 10^8}{d^3}\right)$$

$= \frac{2.033 \times 10^8}{d^3}$

Amplitude Stress $\sigma_a = \sigma_{max} - \sigma_{min}$

$= \frac{3.056 \times 10^8}{d^3} - \left(-\frac{1.018 \times 10^8}{d^3}\right)$

$\sigma_a = \frac{4.073 \times 10^8}{d^3}$

$K_f = 1 + q(K_t - 1) = 1 + 0.9(1.4 - 1) = 1.36$

using Goodman equation

$$\frac{1}{n} = \frac{\sigma_m}{\sigma_u} + \frac{K_f \cdot \sigma_a}{\sigma_{-1}(K_L \cdot K_{SZ} \cdot K_{SF})}$$

$$\frac{1}{2} = \frac{\frac{2.033 \times 10^8}{d^3}}{550} + \frac{1.36 \times \frac{4.074 \times 10^8}{d^3}}{300(1 \times 0.85 \times 0.9)}$$

$d = 177.26\ mm$

~~Say $d = 18\ mm$~~ 180 mm

using Soderberg equation

$$\frac{1}{n} = \frac{\sigma_m}{\sigma_y} + \frac{K_f \cdot \sigma_a}{\sigma_{-1}(K_L \cdot K_{SZ} \cdot K_{SF})}$$

$$\frac{1}{2} = \frac{\frac{2.033 \times 10^8}{d^3}}{320} + \frac{1.36 \times \frac{4.074 \times 10^8}{d^3}}{300(1 \times 0.85 \times 0.9)}$$

$d = 182.74\ mm$ Say 185 mm

d (Goodman method) = 180 mm

d (Soderberg method) = 185 mm.

10

9) Given Data:

Tensile load $P = 25 kN = 25 \times 10^3 N$

$F = 10 kN = 10 \times 10^3 N$

$FoS = 2.5$

yield stress $\sigma = 300 N/mm^2$

$\gamma = 0.25$

To find:

Core dia of bold

Solution:

Stress due to tensile load

$$\sigma_x = \frac{P}{A} = \frac{25 \times 10^3}{(\pi/4 \times d^2)} = \frac{31.83 \times 10^3}{d^2}$$

Stress due to Shear load

$$\tau = \frac{F}{A} = \frac{10 \times 10^3}{\frac{\pi}{4} \times d^2} = \frac{12.732 \times 10^3}{d^2}$$

minimum and maximum principle Stress

$$\sigma_1 = \frac{1}{2}(\sigma_x + \sigma_y) + \sqrt{(\sigma_x - \sigma_y) + 4\tau^2}$$

$$\tau_{xy} = \tau = \frac{12.732 \times 10^3}{d^2}$$

$$\sigma_x = \frac{31.83 \times 10^3}{d^2}$$

ADDITIONAL SHEET

Name: Reg.No:

$$\sigma_1 = \frac{1}{2}\left[\frac{31.83\times10^3}{d^2}\right] + \sqrt{\left(\frac{31.83\times10^3}{d^2}\right)^2 + 4\left(\frac{12.732\times10^3}{d^2}\right)^2}$$

$$= \frac{1}{2}\left[\frac{31.83\times10^3}{d^2} + \frac{40.73\times10^3}{d^2}\right]$$

$$\sigma_1 = \frac{36.267\times10^3}{d^2} \; N/mm^2$$

minimum principal stress

$$\sigma_2 = \frac{1}{2}\left[(\sigma_x+\sigma_y) - \sqrt{(\sigma_x-\sigma_y)^2 + 4\tau_y^2}\right]$$

$$= \frac{1}{2}\left[\frac{31.83\times10^3}{d^2} - \frac{40.73\times10^3}{d^2}\right]$$

$$\sigma_2 = \frac{-4.465\times10^3}{d^2} \; N/mm^2$$

maximum principal stress theory

$$\sigma_1 = \frac{\sigma_y}{n} = \frac{36.267\times10^3}{d^2} \quad \sigma_y = 300 \text{ and FoS} = 2.5$$

$$\frac{36.267\times10^3}{d^2} = \frac{300}{2.5}$$

$d = 17.4\,mm$ Say $18\,mm$

9)

maximum principal Strain theory

$$\sigma_1 - \gamma(\sigma_2 - \sigma_3) = \frac{\sigma_y}{n} \qquad \sigma_y = 0$$

$$\frac{36.267\times10^3}{d^2} - 0.27\left(\frac{-4.465\times10^3}{d^2}\right) = \frac{300}{2.5}$$

$$\frac{373825}{d^2} = \frac{300}{2.5}$$

$d = 17.64$ mm. Say 18 mm

maximum Shear Stress theory

$$\sigma_1 - \sigma_2 = \frac{\sigma_y}{n}$$

$$\frac{36.251\times10^3}{d^2} - \left[\frac{-4.465\times10^3}{d^2}\right] = \frac{300}{2.5}$$

$$\frac{40716}{d^2} = \frac{300}{2.5}$$

$d = 18.42$ mm

Choosing largest of the three diameters.

Core diameter of bolt = 19mm

ADDITIONAL SHEET

Name:

Reg.No:

Given Data:

$T = 250$ N-m $n = 4$

τ_{pa} shaft $= 100$ MPa

(σ_{pr}) shaft $= 2500$ MPa

(τ_{per}) key $= 100$ MPa

(σ_{per}) key $= 250$ MPa

Pa flange $= 200$ MPa

$(\tau_{per}) = 100$ MPa

To find: Design of rigid flange coupling

Step-1

Calculate the diameter of the shaft

$$T = \frac{\pi}{16} \times d^3 \times (\tau_{per})_{shaft}$$

$$250 \times 10^3 = \frac{\pi}{16} \times d^3 \times 100$$

$d = 23.3503$ mm $\simeq 24$ mm

Step.2

Calculate the dimension of the key

(σ_{per}) key $> 2 (\tau_{per})$ key

Hence select a rectangular key

$$w = \frac{d}{4} = \frac{24}{4} = 6 \text{ mm}$$

$$h = d/6 = \frac{24}{6} = 4 \text{ mm}$$

$$l = 1.5d = 1.5 \times 24 = 36 \text{ mm}$$

Length of key is also found by considering Shear and Crushing Stresses

a) Considering Shear Stress

$T = w \times l \times d/2 \times (\tau_{per})_{key}$

$250 \times 10^3 = 6 \times l \times \frac{24}{2} \times 100$

$l = 34.72$ mm

b) Considering Crushing stress

$T = \frac{h}{2} \times l \times \frac{d}{2} \times (\sigma_{pa})_{key}$

$250 \times 10^3 = \frac{4}{2} \times l \times \frac{24}{2} \times 250$

$l = 41.667 \simeq 42$ mm

Selecting a larger value of $l = 42$ mm

Dimension of key $= 6 \times 4 \times 42$ mm

Step-3

Calculate the dimensions of flange coupling

O.D of hub $D = 2d = 2 \times 24 = 48$ mm

$L = 42$ mm

P.C.D of bolts $D_1 = 3d = 3 \times 24 = 72$ mm

$D_2 = 4d = 4 \times 24 = 96$ mm

$D_3 = 1.1 \times d = 1.1 \times 48 = 53$ mm

Thicke of flange $T = 0.5d = 0.5 \times 24 = 12$ mm

protective flange $t_p = 0.25d$

$= 0.25 \times 24 = 6$ mm

$h = 4$

ADDITIONAL SHEET

Name: Reg.No:

Step-4

Design check for hub

$T = \frac{\pi}{16} \times D^3 \times (1-k^4) \times (\tau_{ind})_{hub}$

$250 \times 10^3 = \frac{\pi}{16} \times 48^3 \times (1-65)^4 \times (\tau_{ind})_{hub}$

$(\tau_{ind})_{hub} = 12.28\ N/mm^2$

$(\tau_{ind})_{max} < (\tau_{per})_{hub}$

Step-5

Design check for flange.

$T = \frac{\pi D^2}{2} \times t_f \times (\tau_{ind})_{flange}$

$T \cdot 250 \times 10^3 = \frac{\pi \times 48^2}{2} \times 12 \times (\tau_{ind})_{flange}$

$(\tau_{ind})_{flange} = 5.7564\ N/mm^2$

$5.7564 < 200$ flange is safe.

Step-6

Design of bolts

Bolts are subjected to direct shear and crushing stress

PANDIAN SARASWATHI YADAV ENGINEERING COLLEGE

Madurai - Sivagangai Highway, Thirumansolai Post, Arasanoor, Sivagangai - 630 561

Read the instructions given below carefully before filling in the title page
(To be filled in by the candidate)

REGISTER NUMBER	9	1	2	0	2	0	1	1	4	0	0	2

Student Name	R. AKASH		
Degree / Branch	B. E. Mechanical Engineering.		
Subject Code	ME8593	Subject Title	DESIGN OF Macine

Year / Semester / Sec	III / V / -
Date & Session	28/10/2022-FN
No. of Pages used	

All particulars given are verified

28/10/22

Name and Signature of the Hall Supdt. with date

PART - A		PART - B						GRAND TOTAL (IN WORDS)
Question No.	Marks	Question No.		Marks I	Marks II	Marks III	Total	
1	2	11 (8)	a	8				
2	2		b					Seventy Six.
3	2	12 (9)	a	8				
4	2		b					
5	2	13 (10)	a	8				
6	2		b					GRAND TOTAL
7	2	14	a	24		38/50		
8			b					
9	14	15	a					76 %
10			b					
Total								

Date 28/10/22	Signature of the Examiner	M. [illegible] Signature of the HOD

Instructions to the Candidates :

1. Write your Register No. in the type as shown in the following example

6	2	0	1	1	3	7	5	1	0	2	1

2. Write your Register Number at the Top Right Hand Side of the QUESTION PAPER
3. Use both sides of the paper for answering questions.
4. Possession of any incriminating material and malpractice of any nature shall be punishable as per rules.
5. Answers must be legibly written in ink (Blue, Black or Blue Black)
6. Drawings and Sketches should be drawn using pencil.

8) Given data:

$P = 15\ kN = 15 \times 10^3\ W$

$N = 200\ rpm.$

To find:

Design of the coupling

Soln

(i) Design of Shaft:

$$M_t = \frac{P \times 60}{2\pi N}$$

$$= \frac{15 \times 10^3 \times 60}{2\pi \times 60}$$

$$M_t = 716.19\ N\text{-}m$$

$$M_t = \frac{\pi}{16} \times \tau_s \times d^3$$

$$716.19 = \frac{\pi}{16} \times 65 \times d^3$$

$$d = 38.28\ mm$$

(ii) Dimensions of the coupling

$D = 2.5d = 2.5 \times 40 = 400mm$

$L = 3.5 \times d = 3.5 \times 40 = 140mm$

(iii) Design of sleeve :

$$M_t = \frac{\pi}{16} \times \tau_s \times \left(\frac{D^4 - d^4}{D}\right)$$

~~716.197.2~~

$$716.19 = \frac{\pi}{16} \times \tau_s \times \left(\frac{(100)^4 - (40)^4}{100}\right)$$

$$\boxed{\tau_s = 3.74 \ N/mm^2}$$

(iv) Design of key :- Selection to key ?

$$l = \frac{L}{2} = \frac{140}{2}$$

$$\boxed{l = 70mm}$$

$$M_t = l \times b \times \tau_k \times \frac{d}{2}$$

$$716.19 = 70 \times 12 \times \tau_k \times \frac{40}{2}$$

$$\boxed{\tau_k = 42.63 \ N/mm^2}$$

$$M_t = l \times \frac{h}{2} \times \sigma_{cr} \times \frac{d}{2}$$

$$716.19 = 70 \times \frac{8}{2} \times \sigma_{cr} \times \frac{40}{2}$$

$$\boxed{\sigma_{cr} = 127.9 \ N/mm^2}$$

(v) Design of bolts :-

$$M_t = \frac{\pi^2}{16} \times \mu \times (d_b)^2 \times \sigma_t \times n \times d$$

$$716.19 = \frac{\pi^2}{16} \times 0.3 \times (d_b)^2 \times 70 \times 4 \times 40$$

$$d_b^2 = 345.52$$

$$d_b = 18.594 \ mm$$

$$d_b = 20 \ mm$$

8

---

10) Given data :-

$P = 70 \ kN = 70 \times 10^3 N$

$S_{sy} = 396 \ N/m^3$

$fos = 6$

$S_{yt} = 420 \ N/mm^2$

To find

Design a knuckle joint

Step 1:

$$\sigma_t = \sigma_c = \frac{S_{yt}}{fos} = \frac{420}{6}$$

$$\boxed{\sigma_t = \sigma_c = 70\ N/mm^2}$$

$$\tau = \frac{S_{sy}}{fos} = \frac{396}{6} = 66\ N/mm^2$$

$$\sigma_t = \frac{P}{\frac{\pi}{4} \times d^2}$$

$$70 = \frac{70 \times 10^3}{\frac{\pi}{4} \times d^2}$$

$$\boxed{d = 35.6824\ mm = 40mm}$$

Step 2

$$\tau = \frac{P}{2 \times \pi/4 \times d_p^2}$$

$$66 = \frac{70 \times 10^3}{2 \times \pi/4 \times (d_p)^2}$$

$$\boxed{d_p = 25.9846 = 30mm}$$

$d_n = 1.5\,d = 1.5 \times 40$

$$d_n = 60\,mm$$

Step 3

$$\sigma_c = \frac{P}{2\,d\,P\,t_1} = \frac{70 \times 10^3}{2 \times 30 \times t_1}$$

$$t_1 = 16.666 = 17\,mm$$

$t_1 = 0.75d = 0.75 \times 40$

$$t_1 = 30\,mm$$

$t_2 = 0.5 \times d = 0.5 \times 40$

$$t_2 = 20\,mm$$

Step 4

$$\sigma_c = \frac{P}{d\,t}$$

$$70 = \frac{70 \times 10^3}{30 \times t}$$

$$t = 33.333\,mm$$

$$t = 34\,mm$$

$t = 1.25 \times d = 1.25 \times 40 = 50mm$

$$t = 50mm$$

Step 5

$$\sigma_t = \frac{P}{(D-d_p)t}$$

$$70 = \frac{70 \times 10^3}{(D-30) \times 50}$$

$$D = \frac{70 \times 10^3}{70 \times 50} + 30$$

$$\boxed{D = 50mm}$$

$$\tau = \frac{P}{(D-d_p)t}$$

$$66 = \frac{70 \times 10^3}{(D-30) \times 50}$$

$$= \frac{70 \times 10^3}{66 \times 70} + 30$$

$$= 51.2121 mm$$

$$\boxed{D = 55mm}$$

Step 6

$$\sigma_t = \frac{P}{2(D-d_p)t_1} = \frac{70 \times 10^3}{2(55-30) \times 30}$$

$$\sigma_t = 46.66 \ N/mm^2 < 70 N/mm^2$$

$$\tau = \frac{P}{2(D-d_p)t}$$

$$\tau = 46.66 < 66 N/mm^2$$

ADDITIONAL SHEET

Name: Reg.No:

9) Given data :

$P = 2000 N$

$e = 200 mm$

$l_1 = 50 mm$

$l_2 = 250 mm$

$n_1 = 2$

$n_2 = 3$

To find

Ball size 'd'

Soln

$$f_1 = \frac{P \cdot e \cdot l_1}{n_1 \cdot l_1^2 + n_2 \cdot l_2^2}$$

$$= \frac{20000 \times 200 \times 50}{(2 \times 50^2) + (3 \times 250^2)}$$

$$f_1 = 1038.96 N$$

$$f_2 = \frac{P \cdot e \cdot l_2}{n_1 \cdot l_1^2 + n_2 \cdot l_2^2}$$

$$= \frac{20000 \times 200 \times 250}{(2 \times 50^2) + (3 \times 250^2)}$$

$$f_2 = 5194.8N$$

$f_2 > f_1$

$$\sigma_2 = \frac{f_2}{A_c} = \frac{5194.8}{A_c}$$

$$\tau = \frac{P}{(n_1+n_2)A_c} = \frac{20000}{(2+3)A_c}$$

$$\tau_{max} = \frac{1}{2}\sqrt{\sigma^2 + 4\tau^2} = \frac{1}{2}\sqrt{\left(\frac{5194.8}{A_c}\right)^2 + 4\left(\frac{4000}{A_c}\right)^2}$$

$$= \frac{1}{2}\sqrt{\left(\frac{5194.8}{A_c}\right)^2 + 4\left(\frac{4000}{A_c}\right)^2}$$

$$\tau_{max} = \frac{4768.65}{A_c}$$

$$\tau_{max} = \frac{\sigma_y}{n}$$

A. ssming $\sigma_y = 300\ N/mm^2$ and safety factor = 3

$$\frac{4768.65}{A_c} = \frac{300}{3}$$

$$A_c = 47.68\ mm^2$$

$$A_c = 47.68\ mm^2 (\simeq 58 mm^2)$$

Bold chosen M10 X 1.5 bolt.

8

②

ADDITIONAL SHEET

Name: Reg.No:

Part - A

1) 1) Rigid couplings :-

* Sleeve Couplings
* flange Couplings
* clamp Coupling

2) Flexible Couplings :-

* universal Couplings
* oldham's Couplings
* Bushed pin type Couplings

2

S NO	Keys	Splines
1	A shaft which is having single keyway	A shaft which is having multiple keyways
	Keys are used in Couplings.	Splines are used in automobiles and mechine tools.

2

3)

* Saddle key
* Tangent key
* Sunk key
* Round key and taper pins.

4)

* High clamping
* Small tightening force requirement.
* Easy manufacturing
* Simple design.

5)

* welded connections subjected to moment in a plane of the weld.
* welded connections subjected to moment in a plane normal to the plane of the weld.

6)

Soln

from PSGDB 5.42, for M20

$A_c = 245 mm^2$

$\sigma = \frac{P}{A_c} = P = \sigma \times A_c$

ADDITIONAL SHEET

(13)

Name: Reg.No:

~~Ae~~ = 40 × 245

$P = 9800\ N$

7)

* A thread is designed with

(i) Letter 'M' followed by

(ii) nominal diameter in mm and

(iii) Pitch in mm [for fine pitches only]

$M d \times p$

* If coarse pitches are used then 'p' value is omitted. Thus M20 x 2.5 means

(i) Nominal diameter is 20mm

(ii) 2.5 mm pitch, fine thread.

* M20 means, 20mm nominal diameter with coarse threads.