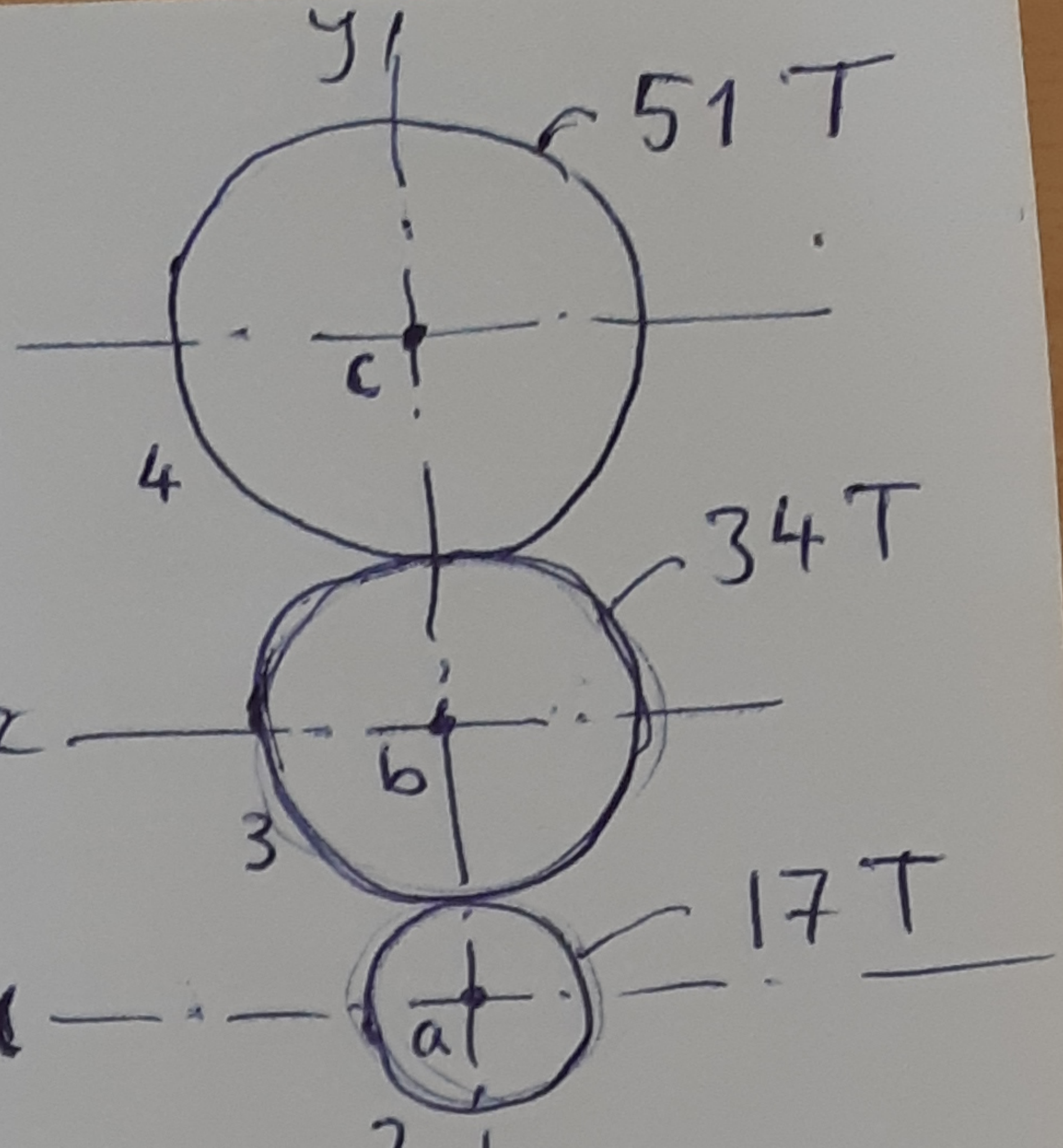
13.31

Shaft 'a' in the figure has a power input of 75 kW at a speed of 1000 rpm in the counter clockwise direction. The gears have a module of 5 mm and a 20° pressure angle. Gear 3 is idler.

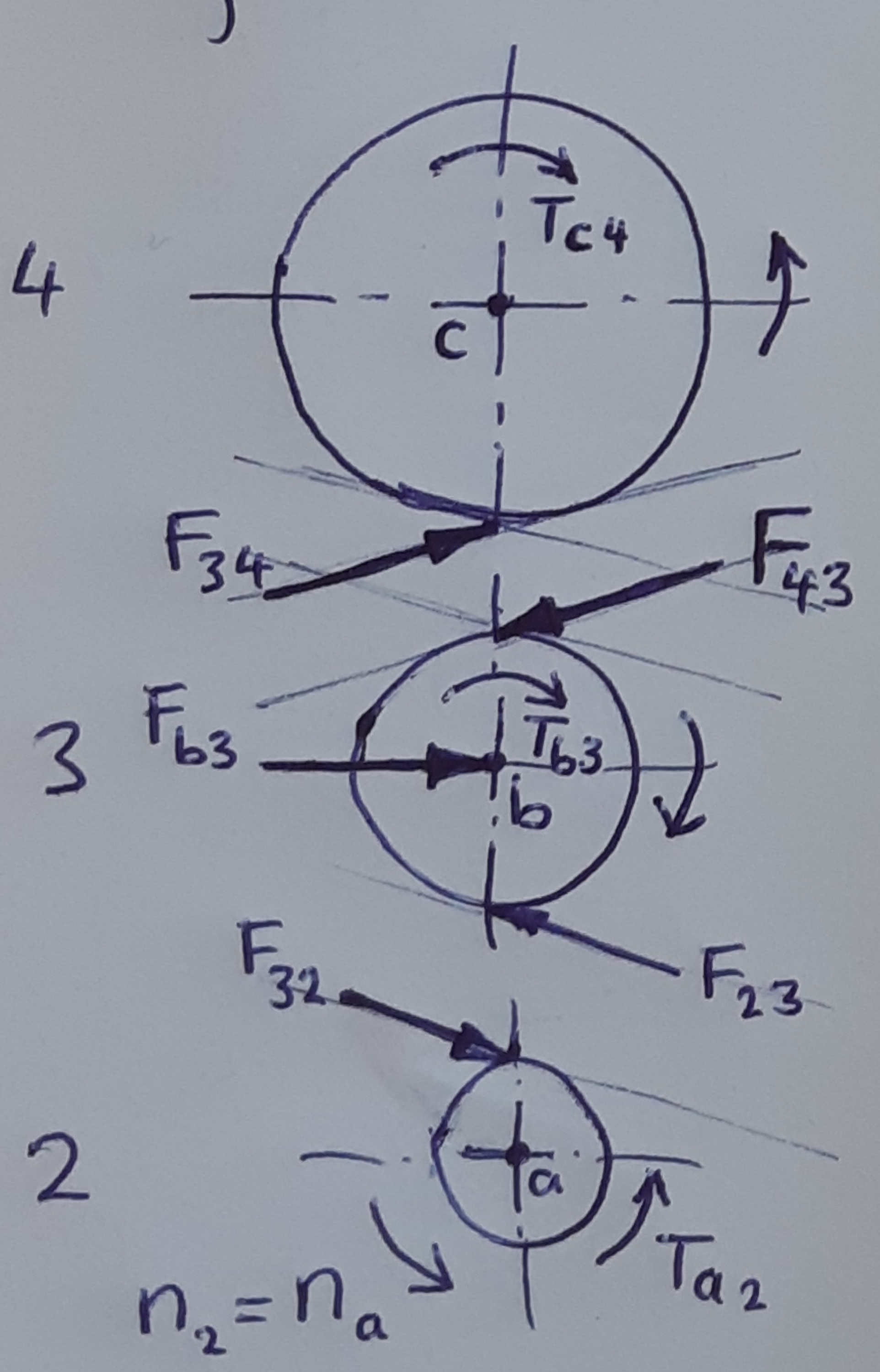


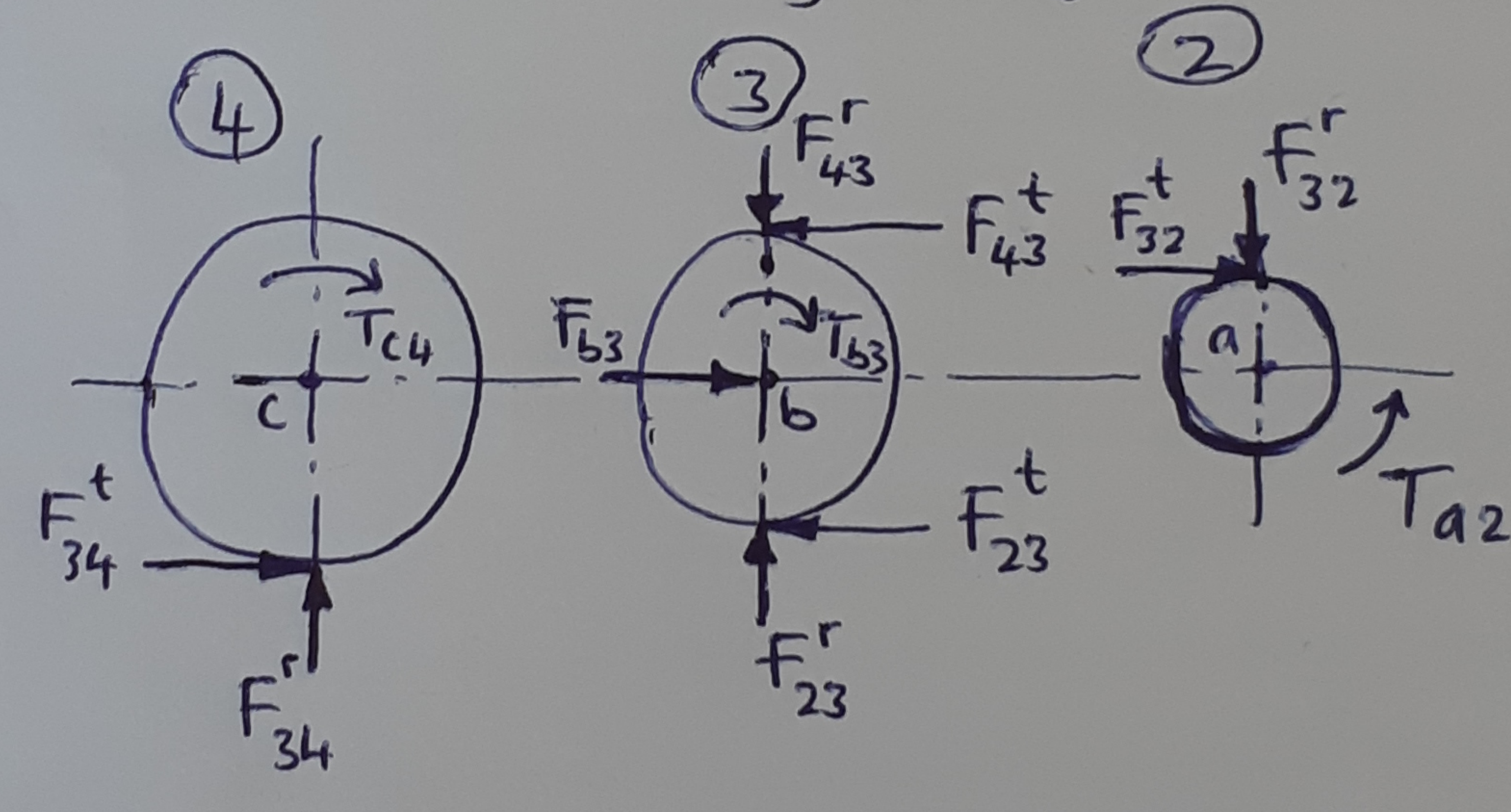
a) Find the force F_{3b} that gear 3 exerts against shaft b.

b) Find the torque T_{4c} that gear 4 exerts on shaft c.

Solution:

First, draw the free-body diagrams (FBD) of each gear.





a) $H = T \cdot w$ $\quad w = \dfrac{2\pi n}{60}$ $\quad$ n in rpm

$$H = \frac{T \cdot 2\pi n}{60} \longrightarrow T = \frac{60H}{2\pi n}$$

$$T_{a_2} = \frac{60(75)10^3}{1000(2\pi)} = 716 \text{ Nm}$$

$$\text{module} = \frac{d}{N} \rightarrow m \cdot N_2 = d_2 = \frac{r_2}{2} \longrightarrow r_2 = \frac{mN_2}{2} = \frac{5(17)}{2} = 42.5 \text{ mm}$$

$$T_{a_2} = F_{32}^t \cdot r_2 \rightarrow F_{32}^t = \frac{T_{a_2}}{r_2} = \frac{716 \text{ Nm}}{42.5 \times 10^{-3}} = 16.8 \text{ kN}$$

Consider FBD of gear 3. Taking moment about point b gives $F_{23}^{t} = F_{43}^{t}$.

$F_{3b} = - F_{b3}$

$\Sigma F_x = 0 \longrightarrow \quad F_{3b} = 2 \cdot F_{23}^{t} = 2(16.8) \rightarrow \boxed{F_{3b} = 33.6 \text{ kN}}$

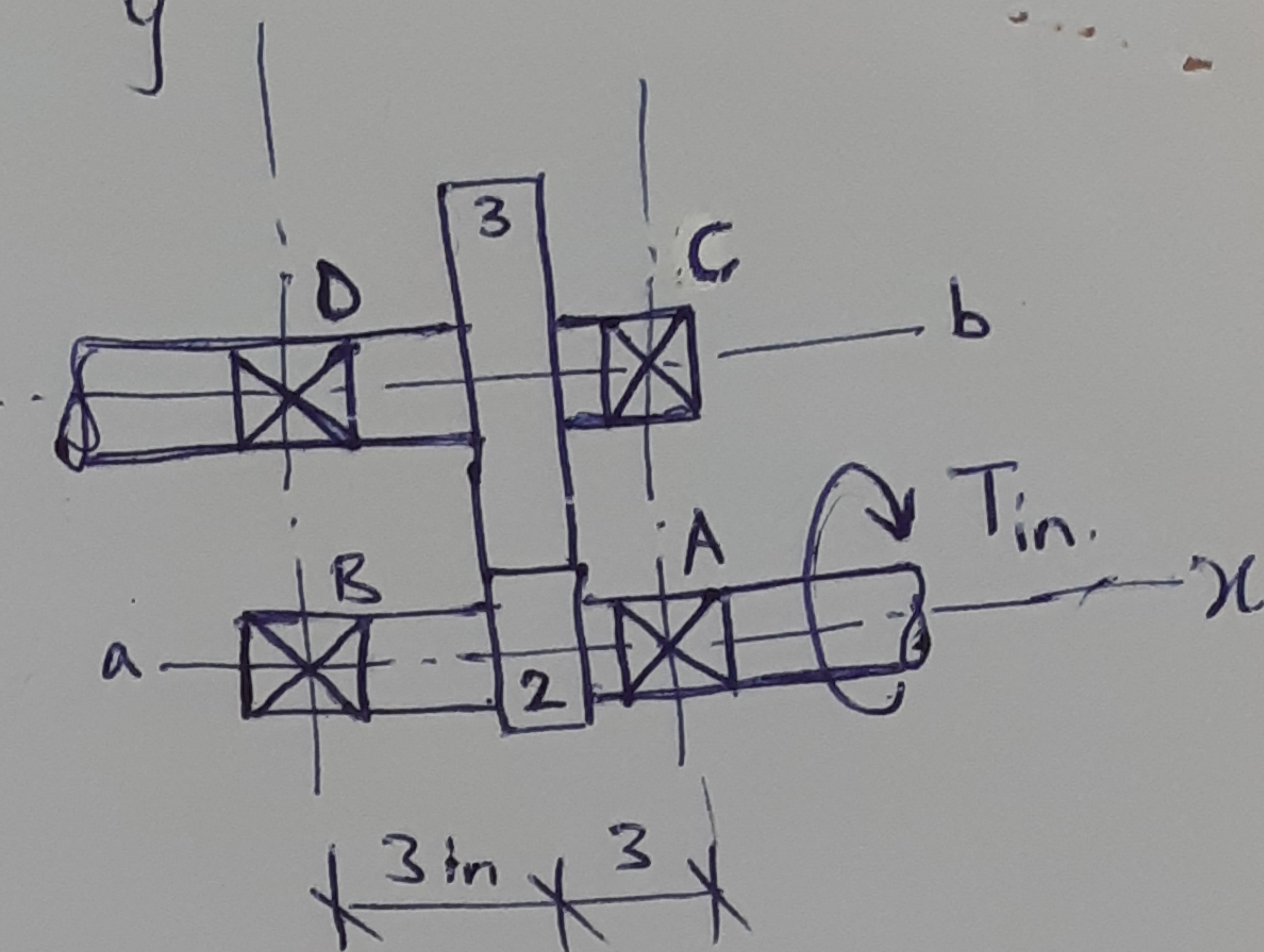
b) $d_4 = m N_4$

$2 r_4 = m N_4 \Rightarrow r_4 = \frac{m N_4}{2} = \frac{5(51)}{2} = 127.5 \text{ mm}$

$T_{c4} = F_{34}^{t} \cdot r_4 = F_{43}^{t} \cdot r_4 = 16.8 \times 127.5$

$T_{c4} = 2,142 \text{ Nm}$. c.w.

13.34



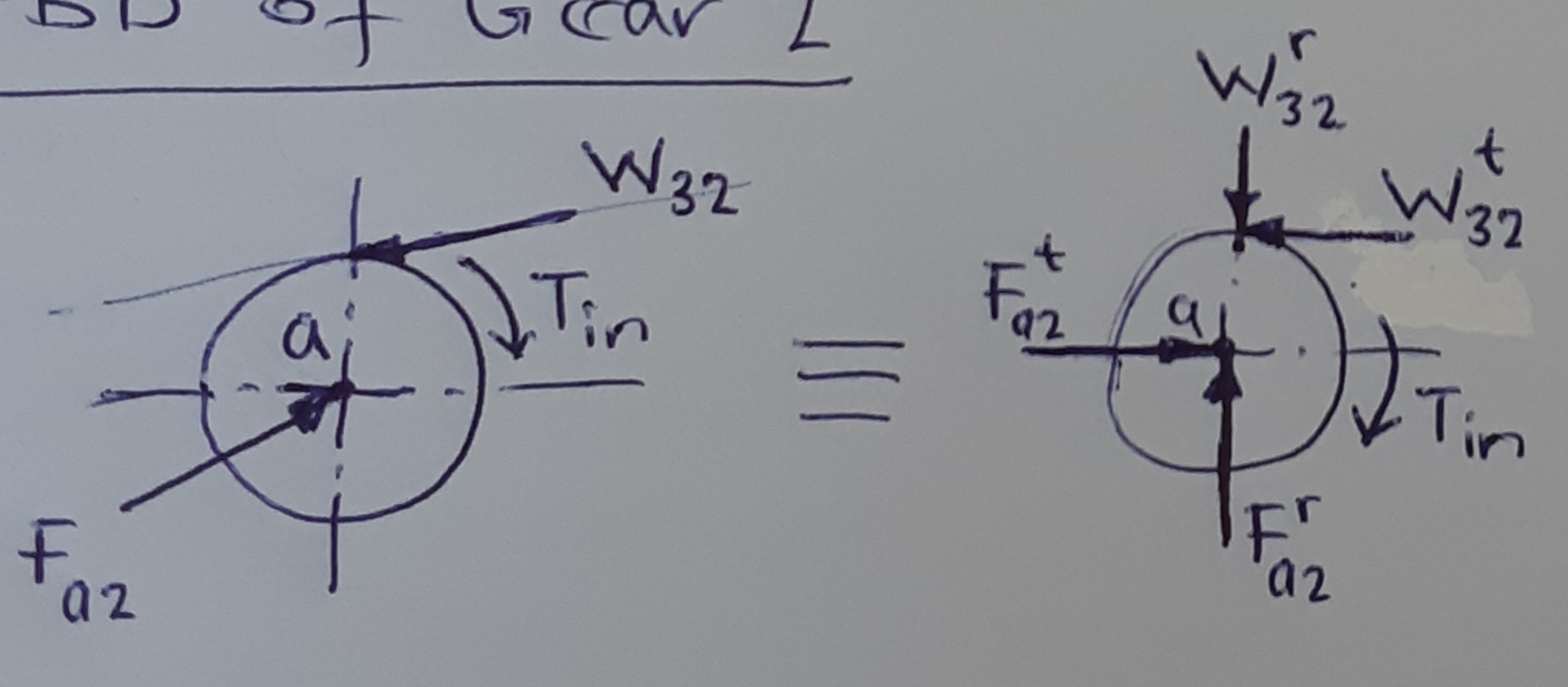
The figure shows a pair of shaft-mounted spur gears having a diametral pitch of 5 teeth/in with an 18-tooth 20° pinion driving a 45-tooth gear. The horsepower input is 32 hp maximum at 1800 rpm. Find the direction and magnitude of the maximum forces acting on bearings A, B, C and D.

Solution

Given: $P = 5$ teeth/in, $N_2 = 18\ T$, $N_3 = 45\ T$

$\phi_n = 20°$, $H = 32$ hp, $n_2 = 1{,}800$ rpm.

FBD of Gear 2



$$\frac{T_{in}}{d_2/2} = \frac{33\,000\ H}{\frac{\pi d_2 n_2}{12}}$$

$$T_{in} = \frac{198\,000\ H}{\pi n_2}$$

$T_{in} = 1{,}120$ lbf-in

$$d_p = d_2 = \frac{N_2}{P} = \frac{18}{5} = 3.6 \text{ in} \qquad d_G = d_3 = \frac{45}{5} = 9.0 \text{ in}$$

$$W_{32}^t = \frac{T_{in}}{d_2/2} = \frac{1{,}120}{3.6/2} = 622 \text{ lbf}$$

$$W_{32}^r = W_{32}^t \cdot \tan 20° = (622)\tan 20 = 226 \text{ lbf}$$

$F_{a2}^t = W_{32}^t = 622 \text{ lbf}$

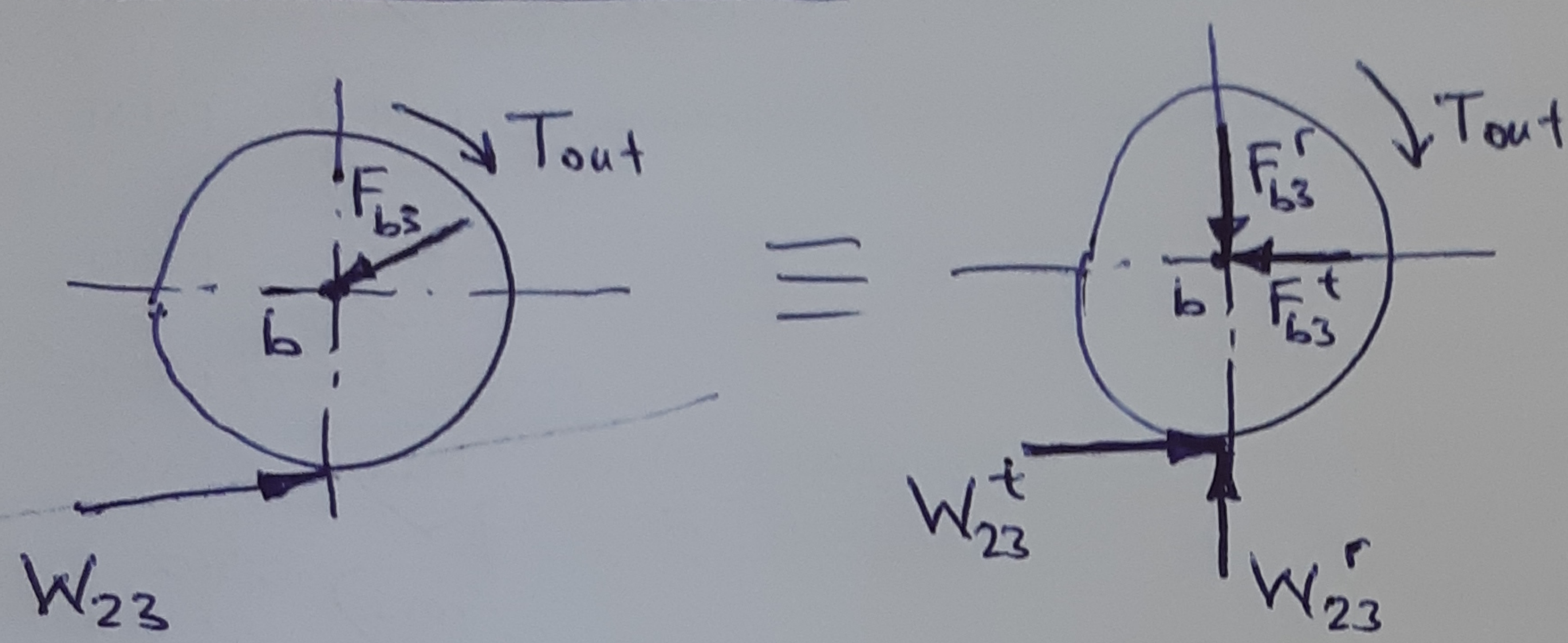
$F_{a2}^r = W_{32}^r = 226 \text{ lbf}$

$F_{a2} = \sqrt{(622)^2 + (226)^2}$

$F_{a2} = 662 \text{ lbf}$

Each bearing on shaft 'a' has the same radial load of $R_A = R_B = \frac{662}{2} = 331 \text{ lbf}$.

FBD of Gear 3



$T_{out} = W_{23}^t \cdot r_3$

$W_{23}^t = W_{32}^t = 622 \text{ lbf}$

$W_{23}^r = W_{32}^r = 226 \text{ lbf}$

$F_{b3} = F_{b2} = 662 \text{ lbf}$

$T_{out} = (622)(4.5) = 2{,}799 \text{ lbf-in}$

$R_C = R_D = \frac{662}{2} = 331 \text{ lbf}$

Each bearing on shaft 'b' has the same radial load of bearing A and B. Thus, all four bearings have the same radial load of 331 lbf.