1 Find absolute the minimum tooth numbers.

relative to planet centres: $R_A + R_B = R_D - R_B = R_E - R_C$

and, since $R \propto z$ (m const) so $= z_D - 20 = 80 - z_C$

$\therefore z_C = 30$; $z_D = 70$

Apply the basic element equations (2):

A-B-F $z_A = 30$ $z_B = 20$

i) $(\omega_A - \omega_F)30 + (\omega_B - \omega_F)20 = 0$

ii) $T_A/30 = T_{B1}/20 = -T_{F1}/50$

where T_{B1} is that portion of T_B which is associated with the element A-B-F etc.

C-E-F $z_C = 30$ $z_E = -80$

iii) $(\omega_E - \omega_F)(-80) + (\omega_C - \omega_F)30 = 0$

iv) $-T_E/80 = T_C/30 = -T_{F2}/(-80+30)$

B-D-F $z_B = 20$ $z_D = -70$

v) $(\omega_D - \omega_F)(-70) + (\omega_B - \omega_F)20 = 0$

vi) $-T_D/70 = T_{B3}/20 = -T_{F3}/(-70+20)$

KINEMATICS solving i) iii) v) with

$\omega_B = \omega_C$ (since B, C compound together)

$\omega_A = +1000$ rpm

$\omega_E = -500$ rpm } in which we select clockwise positive

$\Rightarrow \omega_F = +40$ rpm i.e. 40 rpm clockwise

$\omega_D = -371$ rpm i.e. 371 rpm anticlockwise

KINETICS solving ii) iv) vi) with

$T_{B1} + T_{B3} + T_C = 0$ (no external torque on B-C)

$T_{F1} + T_{F2} + T_{F3} = T_F$

$T_D = P_D/\omega_D$ (P_D is negative since output)

$= -10^3/2\pi(-371/60) = +25.7$ Nm

$T_E = -10^3/2\pi(+40/60) = -238.7$ Nm

$\Rightarrow T_A = +83.7$ Nm

$\therefore P_A = 2\pi\frac{1000}{60} \times 83.7 = 8.77$ kW

i.e. 8.77 kW input since positive

$\Rightarrow T_E = +129.3$ Nm

$\therefore P_E = 2\pi\frac{500}{60} \times 129.3 = -6.77$ kW

i.e. 6.77 kW output since negative.

2 Apply element equations (2) with clockwise positive

31-15-arm (i) $(\omega_{31} - \omega_a).31 + (\omega_p - \omega_a).15 = 0$

(ii) $T_{31}/31 = T_{p1}/15 = -T_{a1}/46$

where T_{p1} and T_{a1} are the portions of external torque applied to compound planet and to arm which are relevant to this element.

33-16-arm (iii) $(\omega_{33} - \omega_a).33 + (\omega_p - \omega_a).16 = 0$

(iv) $T_{33}/33 = T_{p2}/16 = -T_{a2}/49$