

Example Questions – Phase Test 2

Q1) A flat plate clutch has an outer and inner radius of 64 and 14 mm respectively. Calculate the required axial force if it is to transmit 315W at 720 rev/min. The coefficient of friction is 0.34. Use both the uniform wear theory and the uniform pressure theory.

(Constant pressure $\rightarrow 277.1\text{N}$, Constant wear $\rightarrow 315.1\text{N}$)

Q2) Calculate the maximum torque for both constant pressure and wear theories, which can be transmitted by a clutch if it has an outer radius of 115mm and an inner radius of 34mm, a coefficient of friction of 0.3. The axial force may be taken as 400N.

(Constant pressure $\rightarrow 9.82\text{Nm}$, Constant wear $\rightarrow 8.94\text{Nm}$)

Q3) The following data is for a multi-plate clutch.

Number of plates.	5
Speed rev/min	4250
Outside radius mm	81
Inside radius mm	36
Coefficient of friction	0.29
Axial force R is	400 N

a) Calculate the maximum power that the clutch can transmit without slipping based on constant wear theory.

b) Calculate the maximum power that the clutch can transmit without slipping based on constant pressure theory.

(Constant pressure $\rightarrow 31691$, Constant wear $\rightarrow 30202$)

Q4) A multi-plate clutch must transmit 15 kW of power without slipping at 2850 rev/min. The coefficient of friction is 0.36. The inner and outer diameters are 74 and 156 mm respectively. The axial force applied to the plates is 400 N. Determine the number of plates required using:

a) The uniform pressure theory.

b) The uniform wear theory.

Assuming each side of each plate is effective.

(Constant pressure $\rightarrow 1.46$ (2), Constant wear $\rightarrow 1.52$ (2))

Q5) A pulley wheel is 125 mm diameter and transmits 1.15 kW of power at 425 rev/min. The maximum belt tension is 656 N at this point. Calculate the initial tension applied to the stationary belts.

~~449.31 N~~ ~~(1129.65 N)~~

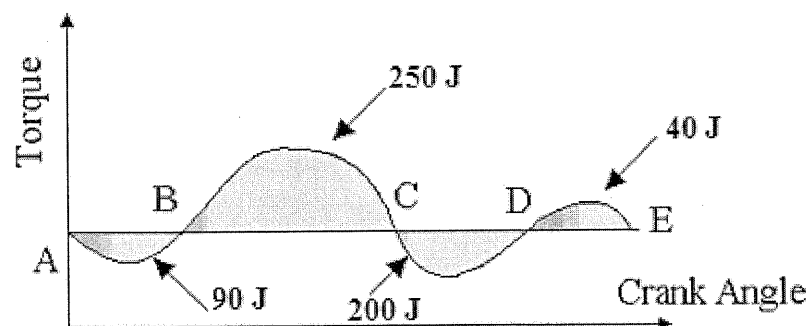
Q6) The tension in a pulley belt is 125 N when stationary. Calculate the tension in each side and the power transmitted when the belt is on the point of slipping on the smaller wheel. The smaller wheel is 110 mm diameter and the coefficient of friction is 0.28. The angle of lap is 172° . The wheel speed is 2100 rev/min.

✓ ✓ ✓
(174.6 N, 75.4 N, 1201 W)

Q7) A belt drive must transmit 8 kW of power at 1150 rev/min. The wheel is 140 mm diameter and the coefficient of friction is 0.29. The lap angle is 143° . The initial belt tension must not exceed 180 N. Calculate the minimum number of belts required.

✓
(7.599 thus 8 belts)

Q8) The diagram shows a torque - angle diagram for a certain machine.

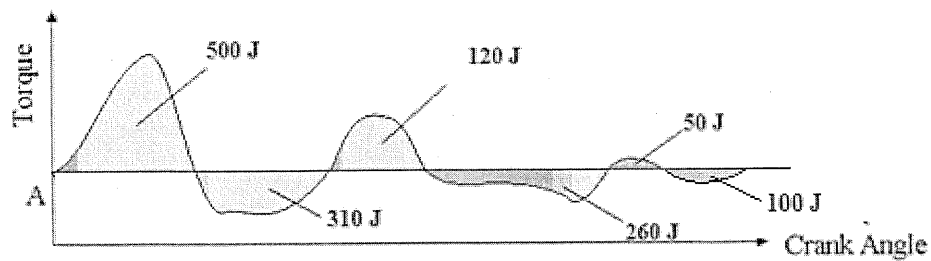


If the speed of the shaft must be maintained between 820 and 1010 rev/min,

- Calculate the moment of inertia of a suitable flywheel.
- Calculate the mass required if the flywheel is to be of the form of a simple disc with an outer radius of 0.26 m.

✓ ✓
(0.131 Kg m^2 , 3.88 Kg)

Q9) The diagram shows a torque - angle diagram for a certain machine.



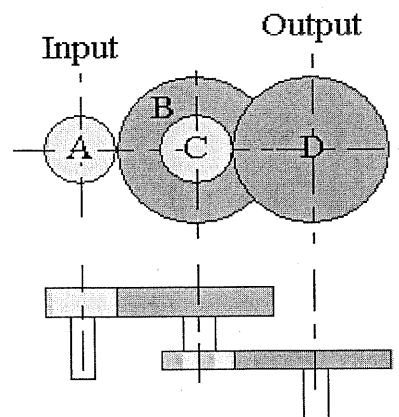
If the speed of the shaft must be maintained between 2100 and 1900 rev/min,

- Calculate the moment of inertia of a suitable flywheel.
- Calculate the mass required if the flywheel is to have a radius of gyration of 0.13 m.

(0.114 Kgm², 6.74 Kg)

Q10) Gear A is the input and revolves at 1800 rev/min clockwise viewed from the left end. The input torque is 21 Nm and the efficiency is 77%.

- Gear A has 38 teeth
- Gear B has 56 teeth
- Gear C has 36 teeth
- Gear D has 50 teeth



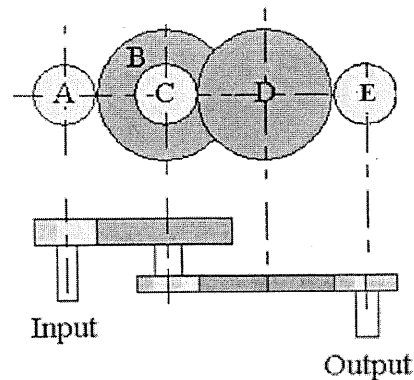
Calculate the following.

- The output speed and its direction.
- The output power.
- The fixing torque.

(879.4 RPM clockwise, 3048W, -54.1 Nm)

Q11) Gear A is the input and revolves at 1100 rev/min, clockwise. The input torque is 8 Nm and the efficiency is 72%.

- Gear A has 30 teeth
- Gear B has 58 teeth
- Gear C has 28 teeth
- Gear D has 56 teeth
- Gear E has 38 teeth



Calculate the following.

- The output speed and its direction.
- The input and output power.
- The fixing torque.

(419.24 RPM anticlockwise, 921.5 W & 663.5 W, 7.11Nm)

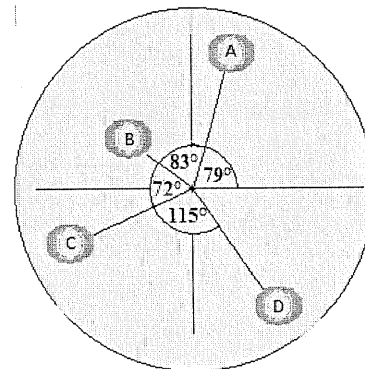
Q12) Find the radius and angular position at which a 5th mass of 0.85 Kg should be placed to statically balance the system shown.

Mass A is 1.040 kg at 115 mm radius.

Mass B is 0.623 kg at 38 mm radius

Mass C is 0.192 kg at 76mm radius

Mass D is 0.16 kg at 108 mm radius



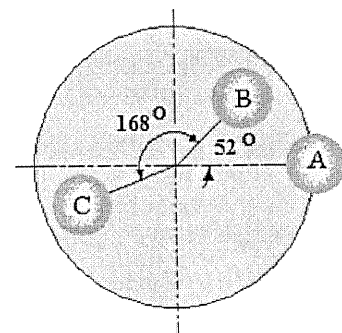
(133.53mm @ 274 degrees)

Q13) Find the 4th mass and its angular position, which must be added at a radius of 90mm to statically balance the system shown.

Mass A is 0.68 kg at 110 mm radius.

Mass B is 0.35 kg at 55 mm radius

Mass C is 0.28 kg at 90 mm radius



(0.611 Kg @ 354 degrees)

Ex 1.

$$r_2 = 0.064 \text{ m}$$

$$r_1 = 0.014 \text{ m}$$

$$P = 315 \text{ W}$$

$$N = 720 \text{ RPM} \Rightarrow \omega = \frac{2\pi N}{60} = \frac{2\pi \times 720}{60} =$$

$$\mu = 0.34$$

$$T = \frac{60P}{2\pi N} = \frac{60 \times 315}{2\pi \times 720} = 4.18 \text{ Nm}$$

uniform pressure

$$T = \frac{2}{3} \mu W \frac{(r_2^3 - r_1^3)}{(r_2^2 - r_1^2)}$$

$$W = \frac{3T(r_2^2 - r_1^2)}{2\mu(r_2^3 - r_1^3)} = \frac{3 \times 4.18 \times (0.064^2 - 0.014^2)}{2 \times 0.34 \times (0.064^3 - 0.014^3)}$$

$$W = \underline{\underline{277.26 \text{ N}}}$$

Constant wear

$$T = \frac{\mu W(r_2 + r_1)}{2}$$

$$W = \frac{2T}{\mu(r_2 + r_1)} = \frac{2 \times 4.18}{0.34(0.064 + 0.014)} = \underline{\underline{315.2 \text{ N}}}$$

Q2/
 $r_2 = 0.115 \text{ m}$
 $r_1 = 0.034$
 $\mu = 0.3$
 $W = 400$

$$T = \frac{\mu W (r_2 + r_1)}{2} = \frac{0.3 \times 400 \times (0.115 + 0.034)}{2}$$

$$T = \underline{8.94 \text{ Nm}}$$

$$T = \frac{2 \mu W (r_2^3 - r_1^3)}{3 (r_2^2 - r_1^2)} = \frac{2 \times 0.3 \times 400 \times (0.115^3 - 0.034^3)}{3 \times (0.115^2 - 0.034^2)}$$

$$T = \underline{9.82 \text{ Nm}}$$

Q3/
 $n = 5$
 $N = 4250 \text{ RPM}$
 $r_2 = 0.081 \text{ m}$
 $r_1 = 0.036 \text{ m}$
 $\mu = 0.29$
 $W = 400.$

a) $T_{\max} = \frac{2 n \mu W (r_2 + r_1)}{2} = \frac{2 \times 5 \times 0.29 \times 400 (0.081 + 0.036)}{2}$

$$T_{\max} = 67.86 \text{ Nm}$$

$$P_{\max} = \frac{2 \pi N}{60} \times T = \frac{2 \pi \times 4250}{60} \times 67.86$$

$$P_{\max} = \underline{30,202 \text{ W.}}$$

b) $T_{\max} = \frac{2 \mu W (r_2^3 - r_1^3) \times 2n}{3 (r_2^2 - r_1^2)}$

$$T_{\max} = 71.2 \text{ Nm}$$

$$P_{\max} = \underline{31690.94 \text{ W}}$$

Q4/
 $P = 15000 \text{ W}$
 $N = 2850$
 $\mu = 0.36$
 $r_2 = 0.156$
 $r_1 = 0.074$
 $W = 400 \text{ N}$

$$T = \frac{60P}{2 \pi N} = \frac{60 \times 15000}{2 \pi \times 2850} = 50.259 \text{ Nm}$$

a) $n = \frac{2T}{2 \mu W (r_2 + r_1)} = \frac{2 \times 50.259}{2 \times 0.36 \times 400 (0.156 + 0.074)}$
 $n = 1.52 \therefore 2.$

b) $n = \frac{3T (r_2^2 - r_1^2)}{4 \mu W (r_2^3 - r_1^3)} = \frac{3 \times 50.259 (0.156^2 - 0.074^2)}{4 \times 0.36 \times 400 (0.156^3 - 0.074^3)}$
 $n = 1.46 \therefore 2.$

Q5/ $d = 0.125 \text{ m}$
 $P = 1150 \text{ W}$
 $N = 425 \text{ RPM}$
 $F_1 = 656 \text{ N}$

$$v = \omega r = \frac{2\pi \times 425}{60} \times \frac{0.125}{2} = 2.782 \text{ m/s}$$

$$P = v(F_1 - F_2)$$

$$F_1 - F_2 = \frac{P}{v} \quad F_2 = F_1 - \frac{P}{v}$$

$$F_2 = F_1 - \frac{P}{v} = 656 - \frac{1150}{2.782} = 242.63 \text{ N}$$

$$F_1 + F_2 = 898.63 \text{ N}$$

$$\text{Initial} = \frac{F_1 + F_2}{2} = \underline{\underline{449.31 \text{ N}}}$$

Q6/ $F_i = 125 \text{ N}$

$$d = 0.11$$

$$\mu = 0.28$$

$$\theta = 172^\circ =$$

$$N = 2100 \text{ RPM}$$

$$180^\circ = \pi$$

$$172^\circ = \frac{172 \times \pi}{180} = 3.002 \text{ rad}$$

$$e^{\mu\theta} = \frac{F_1}{F_2}$$

$$\frac{F_1}{F_2} = e^{0.28 \times 3.002} = 2.318$$

$$F_1 = 2.318 F_2$$

$$\text{Constant} = 125 + 125 = 250$$

$$250 = F_1 + F_2$$

$$250 = F_2 + 2.318 F_2$$

$$F_2 = \frac{250}{3.318} = \underline{\underline{75.35 \text{ N}}}$$

$$F_1 = \underline{\underline{174.65 \text{ N}}}$$

$$P = v(F_1 - F_2) = \frac{2\pi \times 2100 \times 0.11}{60 \times 2} (174.65 - 75.35) = \underline{\underline{1201 \text{ W}}}$$

Q7/ $P = 8000 \text{ W}$

$N = 1150 \text{ RPM}$

$d = 0.14$

$\mu = 0.29$

$\theta = 143^\circ$

$F_t = 180 \text{ N}$

$F_1 + F_2 = 360 \text{ N}$

$\frac{F_1}{F_2} = e^{\mu\theta} = e^{0.29 \times \frac{143 \times \pi}{180}} = 2.0622$

$F_1 = 2.0622 F_2$

$360 = 3.0622 F_2$

$F_2 = 117.56 \text{ N}$

$F_1 = 242.44 \text{ N}$

$P = \frac{2\pi \times 1150}{60 \times 2} \times 0.14 (242.44 - 117.56) = 1053 \text{ W per belt}$

$n = \frac{8000}{1053} = 7.599 \therefore 8 \text{ belts}$

Q8/ $N_2 = 1010 \text{ RPM}$

$N_1 = 820 \text{ RPM}$

Energy

A E_A

B $E_A + 90$

C $E_A + 160$

D $E_A - 40$

E 0

$BW = 160 + 90 = 250 \text{ S}$

$N_m = \frac{1010 + 820}{2} = 915 \text{ RPM} \Rightarrow 95.819 \text{ rad/s}$

$\phi = \frac{N_2 - N_1}{N_m} = 0.2077$

a) $I = \frac{BW}{\omega_m^2 \phi} = \frac{250}{95.819^2 \times 0.2077} = 0.1315 \text{ kgm}^2$

b) $I = \frac{m r^2}{2} \quad m = \frac{2I}{r^2} = \frac{2 \times 0.131}{0.26^2} = 3.89 \text{ kg}$

Q9/

$$N_2 = 2100 \text{ RPM}$$

$$N_1 = 1900 \text{ RPM}$$

$$BW = 500 - 0 = 500 \text{ S.}$$

- A E_A
- B $E_A + 500$
- C $E_A + 190$
- D $E_A + 310$
- E $E_A + 50$
- F $E_A + 100$
- G E_A .

$$N_m = 2000 \text{ RPM} = 209.44 \text{ rad/s.}$$

$$\phi = \frac{2100 - 1900}{2000} = \underline{\underline{0.1}}$$

$$a) I = \frac{BW}{\omega_m^2 \phi} = \frac{500}{209.44^2 \times 0.1} = 0.114 \text{ kgm}^2$$

$$b) I = mk^2 \quad m = \frac{I}{k^2} = \frac{0.114}{0.13^2} = 6.74 \text{ kg}$$

Q10/

$$N_1 = 1800 \text{ RPM (Clockwise)}$$

$$T_1 = 21 \text{ Nm}$$

$$\eta = 0.77$$

$$t_a = 38$$

$$t_b = 56$$

$$t_c = 36$$

$$t_d = 50$$

$$GR = \frac{t_b}{t_a} \times \frac{t_d}{t_c} = \frac{56}{38} \times \frac{50}{36} = \underline{\underline{2.047}}$$

$$GR = \frac{N_1}{N_2} \quad \therefore N_2 = \frac{N_1}{GR} = \frac{1800}{2.047} = \underline{\underline{879.34 \text{ RPM (Clockwise)}}}$$

$$P_2 = P_1 \times \eta = \left(\frac{2\pi \times 1800}{60} \times 21 \right) \times 0.77 = 3048 \text{ W.}$$

$$T_2 = \frac{60P}{2\pi N} = \frac{60 \times 3048}{2\pi \times 879.34} = 33.1 \text{ Nm. (Clockwise)}$$

$$T_1 + T_2 + T_3 = 0$$

$$T_3 = -T_1 - T_2 = -21 - 33.1 = \underline{\underline{-54.1 \text{ Nm}}}$$

Q11/ $N_1 = 1100 \text{ RPM}$ (clockwise)

$$T_1 = 8 \text{ Nm}$$

$$\eta = 0.72$$

$$t_a = 30$$

$$t_b = 58$$

$$t_c = 28$$

$$t_d = 56$$

$$t_e = 38$$

$$GR = \frac{58}{30} \times \frac{56}{28} \times \frac{38}{56} = 2.624.$$

$$N_2 = \frac{N_1}{GR} = \frac{1100}{2.624} = \underline{\underline{419.21 \text{ RPM}}} \text{ (anticlockwise).}$$

$$P_1 = \frac{2\pi N_1}{60} \times T_1 = \frac{2\pi \times 1100}{60} \times 8 = \underline{\underline{921.53 \text{ W}}}.$$

$$P_2 = P_1 \times \eta = 921.53 \times 0.72 = \underline{\underline{663.5 \text{ W}}}$$

$$T_2 = \frac{60P}{2\pi N} = \frac{60 \times 663.5}{2\pi \times 419.21} = 15.11 \text{ Nm. (anticlockwise).}$$

$$T_h = -T_1 - T_2 = -8 - (-15.11) = +7.11 \text{ Nm (clockwise).}$$

Q12/

	mass	r	mr
A	1.04	115	119.6
B	0.623	38	23.67
C	0.192	75	14.4
D	0.160	108	17.28

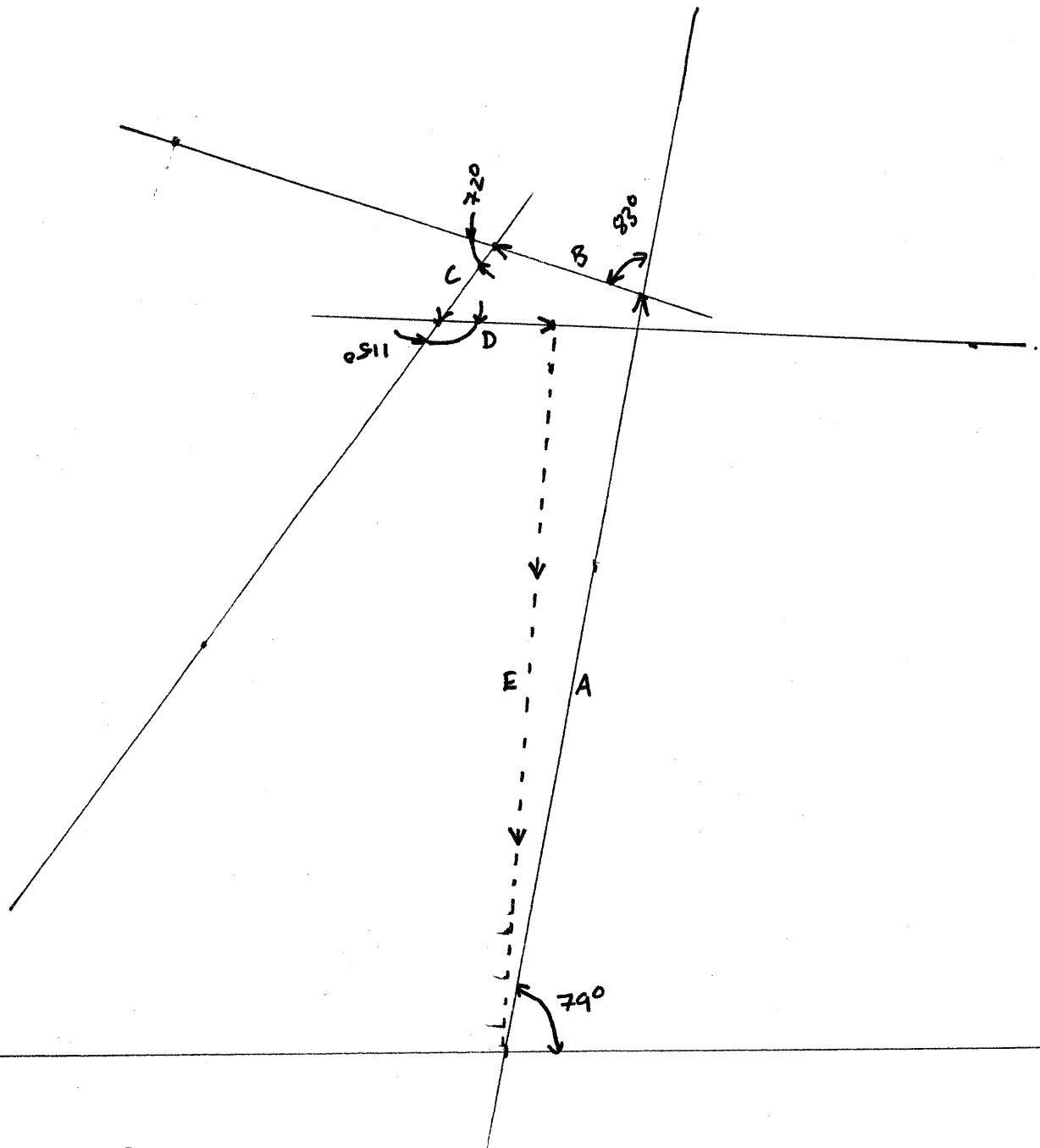
See attached.

Q13/

	mass	r	mr
A	0.68	110	74.8
B	0.35	55	19.25
C	0.28	90	25.2

See attached.

Q12 (cont).

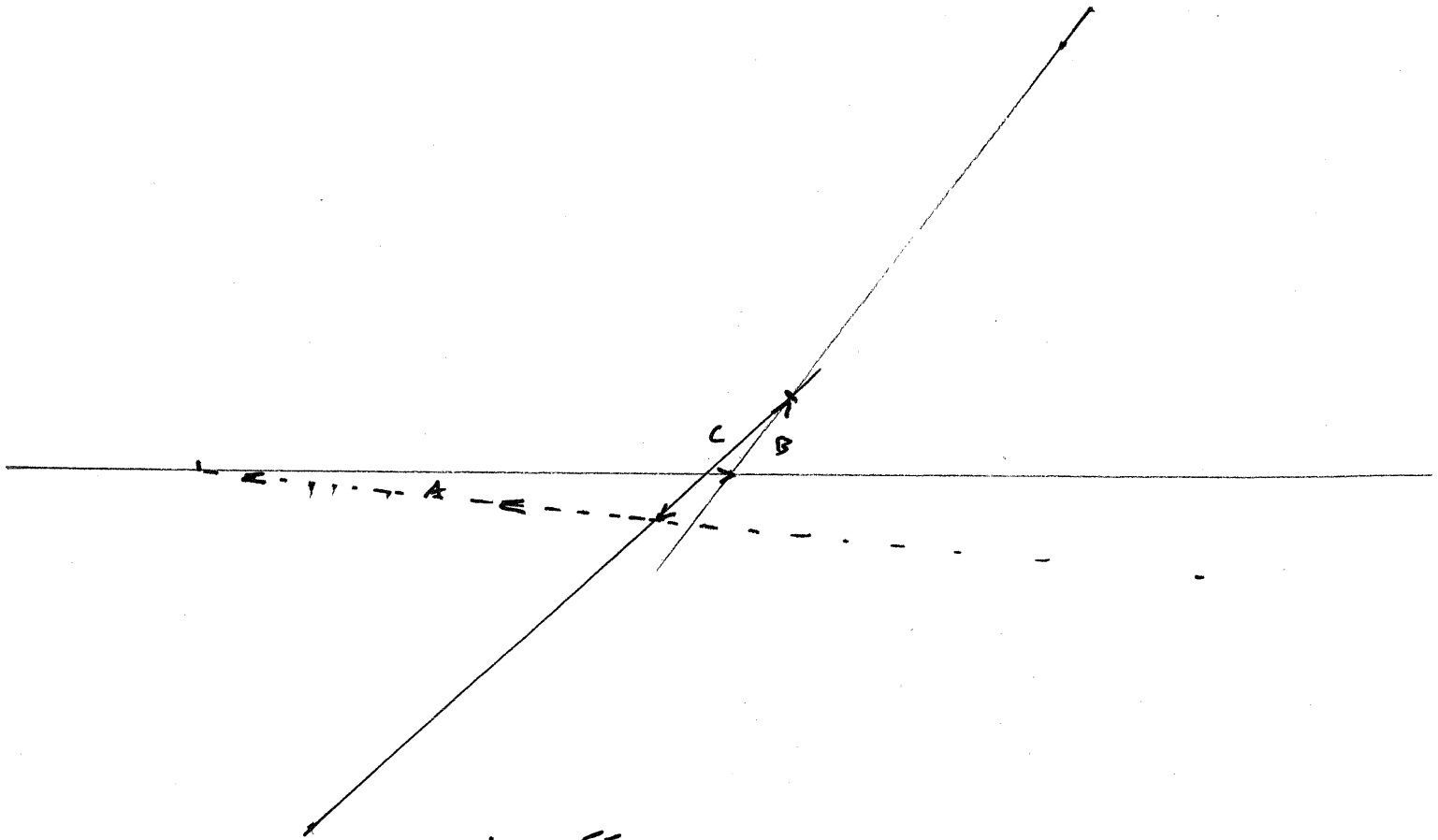


length E. = 113.5 mm.

$M_E \Gamma_E = 113.5 \text{ ugmm.}$

$$\Gamma_E = \frac{113.5}{M_E} = \frac{113.5}{133.53} \text{ mm.} \quad @ \quad 360 - 86^\circ = 274^\circ \text{ to horizontal.}$$

Q13 (cont)



$$L_D = 55 \text{ mm}$$

$$M_D r_D = 55 \text{ kgmm.}$$

$$m_D = \frac{55}{r_D} = \frac{55}{90} = \underline{0.611 \text{ kg}}$$

@ 354° to
horizontal.