General approach – analyse system energy to find necessary brake torque; analyse brake to discover the corresponding actuation force exerted by spring; finally analyse spring stiffness to determine the deflexion necessary to yield required force.

Initial velocity $v_0 = 2$ m/s $\therefore \omega_0 = \frac{v_0}{r} = \frac{2}{0.6} = 3.33$ rad/s

$\therefore v_m = \frac{1}{2} v_0 = 1$ m/s ; $\omega_m = \frac{1}{2}\omega_0 = 1.67$ rad/s

Braking time $\Delta t = 2$ s

$\therefore$ from (1) $\Delta\theta = \omega_m \Delta t = 3.33$ rad

& skip displacement over braking $\Delta h = r\Delta\theta = 2$m

Initial system energy : (m_L = loaded, m_E = empty)

KE of skips $= \frac{1}{2}(m_L + m_E)v_0^2 = \frac{1}{2}(1.5+0.5)\,2^2 = 4$ kJ

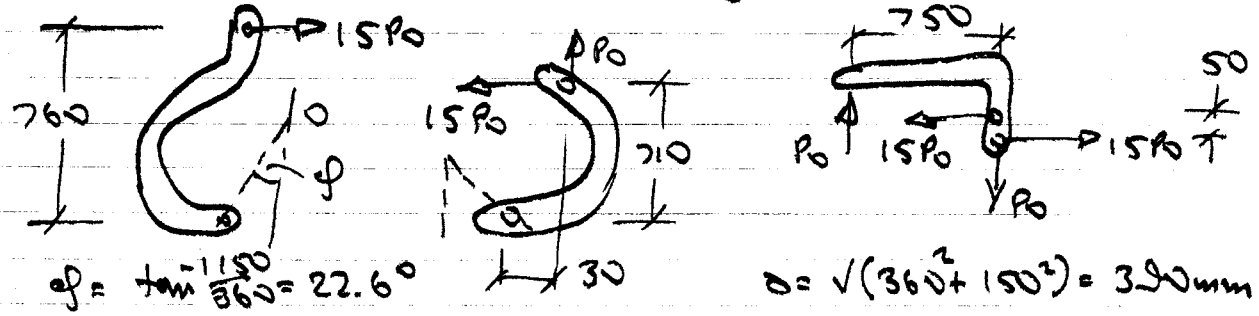
KE of rope drum $= \frac{1}{2} I \omega_0^2 = \frac{1}{2} \times 0.5 \times 3.33^2 = 2.78$ kJ

PE loss of skips $= (m_L - m_E) g \Delta h = (1.5-0.5) \times 9.81 \times 2 = 19.62$ kJ

$\therefore$ work done by brake $= U = 26.4$ kJ

& braking torque, $T = U/\Delta\theta = 26.4/3.33 = 7.92$ kNm

Brake analysis – let P_0 be spring force:



$\phi = \tan^{-1}\frac{150}{360} = 22.6°$

$a = \sqrt{(360^2 + 150^2)} = 390$mm

for the LH shoe:

$\theta_p = 90 - \phi = 67.4°$

for the RH shoe:

$P = \sqrt{(15^2+1^2)}P_0 = 15.03P_0$

– the moment arm, e, is

$15.03P_0 e = 15P_0 \times 710 + P_0 \times 30$

i.e. $e = 710.4$ mm

– the force inclination is

$\theta_p = 90 - \phi - \tan^{-1} 1/15 = 63.6°$

problem 8				
drum diameter	600.0 mm	centre-to-hinge distance	390.0 mm	
lining limits	0.0 140.0 deg	brake actuating force	1.230 kN	
lining width	144.57 mm	coefficient of friction	0.300	
		1 leads	2 trails	
ratio of shoe-to-brake actuating forces		15.00	15.03	
actuating force's moment arm about hinge		760.0	710.4	mm
actuating force's inclination		67.4	63.6	deg
inclination of 2's axis relative to 1		-45.2		deg
mean pressure on shoe lining		330.4	500.0	kPa
shoe's contribution to, and total torque		3151.2	4768.8	7920.0 Nm
sensitivity of shoes and of brake		0.809	1.308	1.110
shoe hinge and drum bearing reactions		49.126	62.473	24.692 kN

Hence program 'Brake' gives the required actuation force as

$P_0 = 1230$ N.

(Note the damning pressure-input – we are not interested in brake internals, only want overall P_0-to-T mechanical advantage.)

For the spring $k = Gd/8nC^3 = \frac{79.3\times10^3 \times 10}{8 \times 10 \times 63} = 45$ N/mm

$\therefore$ To give a force of 1230 N, the spring must be compressed $1230/45 = 26.8$, say 27 mm.