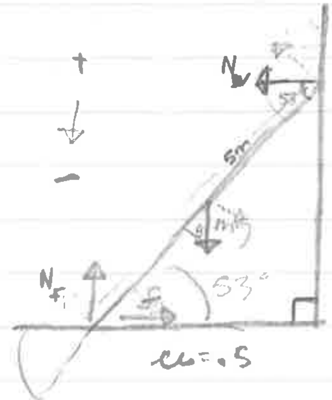
PS 10

1.

a.



Ladder: 30 kg

person 50 kg

b. max friction = μN_1

$N_1 = (m_L + m_P) g = 800N$

friction = $.5 \cdot 800N = \boxed{400N}$

c. Normal force of wall = frictional Force

d. x: $\Sigma F = ma = 0$

Friction − N_{wall} = 0

y: $\Sigma F = ma = 0$

$N_{floor} - mg(\text{person} + \text{ladder}) = 0$

e. center of rotation: base of ladder (N_f + f are negligible)

$\Sigma T = 0 = T_{wall} - T_{ladder} - T_{person}$

$N_{wall} \cdot \sin\theta \cdot 5m - m_L \cdot g \cos\theta \cdot 2.5 - m_p \cdot g \cos\theta \cdot x = 0$

position of person is at base, so $x = 0$

$N_w \cdot \sin 53 \cdot 5 - 30 \cdot 10 \cdot \cos 53° \cdot 2.5 = 0$

$\boxed{N_{wall} = 113.0 \text{ Newtons}}$

f. The Normal force of the wall < frictional force

the ladder does not slip.

g. walking up the ladder would change: this would increase torque in the downward direction, thus increasing Normal force of the wall to maintain equilibrium.

h. $T_{wall} - T_{ladder} - T_{person} = 0$

(theoretically)

$N_w \cdot \sin 53 \cdot 5_m - m_L \cdot g \cos 53 \cdot 2.5_m - m_p \cdot g \cos 53 \cdot 5_m = 0$

$N_w \cdot \sin 53 \cdot 5_m - 30 \cdot 10 \cdot \cos 53 \cdot 2.5 - 50 \cdot 10 \cdot \cos 53 \cdot 5 = 0$

$N_w = 2450$ Newtons

$N_{wall} > f$, the ladder will slide.

i. $\Sigma T = 0 = T_N - T_L - T_P = 0$

$N_{wall} =$ friction $= 400N$

$400 \cdot \sin 53 \cdot 5_m - 30(10) \cdot \cos 53 \cdot 2.5 - 50(10) \cos 53 \cdot x_m = 0$

$x = 3.8$ m along the ladder $= 2.3$m Horizontally

• you can go up 3.8 meters before it will fall

$= 3$m Vertically

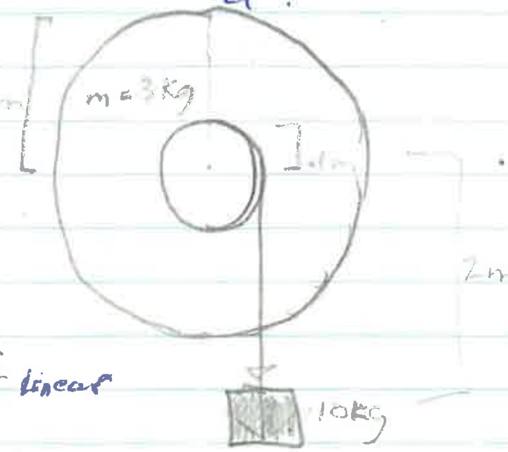
J. if θ were $60°$, the weight of the ladder and person's perpendicular component would be smaller, thus applying less torque and allowing the person to go to a further distance up.

The work now goes into spinning wheel and speeding up the hanging mass. The tension is now < 100N because the hanging 10kg mass is accelerating downward!

2\. a. ~~i. the 200 J goes into spinning the wheel~~

~~ii. the tension is still 100 N (10kg · 10m/s²) (answers will be the same)~~

iii Tension is the same



b. PE → KE$_{rot}$ + KE$_{linear}$

$mgh = \frac{1}{2} I \omega^2 + \frac{1}{2} m v^2$

units!

$I = \frac{1}{2} m r^2 \qquad v = \omega r \qquad \omega \cdot r$

$10\,kg\,(10\,m/s^2)(2\,m) = \frac{1}{2}\left(\frac{1}{2}(3)(.3^2)\right)\omega^2 + \frac{1}{2}(10)(\omega \cdot 0.1\,m)^2$

-5 pts!

$200\,J = .0675\,\omega^2 + .05\,\omega^2$

$\boxed{\omega = 41.25 \text{ rad/sec}}$ $\quad \boxed{\Delta t \sim .91\,s} = \frac{2m}{V_{ave}}$

d. dynamics: $\sum \vec{T} = I \vec{\alpha}$

$mg \cdot r = I\alpha \qquad$ Parallel axis I

$10\,kg\,(10\,m/s^2)(.1\,m) = \left(\frac{1}{2}(3\,kg)(.3\,m)^2 + 10\,kg\,(.1\,m)^2\right)\alpha$

$43 \text{ rad/s}^2 = \alpha$

c. Block: $mg - T = ma \qquad \alpha = \frac{a}{r}$

$43 = \frac{a}{.1} \qquad \boxed{a = 4.3\,m/s^2}$

$100N - T = 10kg\,(4.3\,m/s^2)$

$10 \cdot 10 - T = 10(4.3)$

$\boxed{T = 57 \text{ Newtons}}$

e) They do!

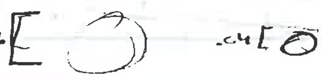
3. A $200N \cdot .2m = \boxed{40\ n \cdot m}$, $\frac{60\ revs}{m} = \boxed{2\pi\ rad/s}$

B. $60\ revs/m = 1\ rev/s$ $\quad p = w/s$

$2\pi \cdot .2 = 1.26$ m circumference

$200N \cdot 1.26m$ = Work in 1 rotation, also 1 second

$\frac{200N \cdot 1.26m}{1s} : \boxed{252\ watts}$

C $.2$  $.04$

Torque crank → torque chainring → torque sprocket

since the crank is not angularly accelerating,

$\Sigma T = 0 = T_{leg} - T_{chain}$

$200N \cdot .2m - Torque_{chain} = 0$

Torque on the chain $= 40\ n \cdot m$

$T = F \cdot r$ so $40\ n \cdot m = F \cdot (.10)$

$400 = F$

$\boxed{\text{the tension in the chain is } 400N}$

$400N \cdot .02 =$ $\boxed{\text{8 Nm of torque acting on back wheel}}$

D. Speed of chain = circumference chainring / 1 second

$= \frac{2\pi \cdot .10m}{1} = .628\ m/s =$

$T_{chain} = 400N$

$400N \cdot .628\ m/s = \boxed{251.3\ watts}$

E. rear sproket is $\frac{1}{5}$ the size of front chain ring so the speed will be $5\times$ greater

$1\ rev/s \times 5 = 5\ revs/s \times \frac{2\pi}{1\ rev} = \boxed{10\pi\ rad/s}$

$10\pi\ rad/s = \frac{v}{r} = \frac{v}{.02}$ $\quad v = .628\ m/s$

$P = F \cdot V$ = chain tension $\cdot$ V of sprocket $= 400 \cdot .628\ m/s$ $\boxed{251\ watts}$

F. $\alpha_{wheel} = 0$ so $\Sigma \vec{\tau} = 0$

$$400N \cdot .02m - F_f \cdot .35m = 0$$

Force of friction on wheel = $\boxed{22.8\,N}$

G. ~~wheel speed ... 10π rad/s~~ $\omega_{wheel} \sim 10\pi/s$

$\omega = \frac{v}{r}$ $\quad 10\pi/s = \frac{v}{.35m}$ $\quad \boxed{v \approx 11\,m/s}$

$P = F \cdot v = 22.8N \cdot 11m/s = \boxed{250.7 \text{ Watts}}$

H. i. Tension stays same because "front" gearing stays same $T = 400N$

Torque $= 400N \cdot (.04m) = \boxed{16\,N \cdot m}$

?

ii. $P_{wheel} = F \cdot v = 400 \cdot v$ $\quad \tau \cdot \omega = 2P_0$ $= \underline{500W}$

double $\rightarrow \tau$, same $\rightarrow \omega$

~~new gear is 1/2.5 the size of the front gear, so the speed is 2.5x greater, compared to the original 5x as fast.~~

~~$\omega_{front} \times 2.5 = \omega_{rear}$~~

now chain must move at twice the speed

This Question is impossible to answer because either the pedal rate or the bike's velocity must remain constant. The reason the first questions could be answered was because the ω of the pedals was given, now neither are given.

Feet pedal twice as fast

good → I see video