Simple Friction Comparison (Maths vs Graphical)

Tuesday, 15 March 2011
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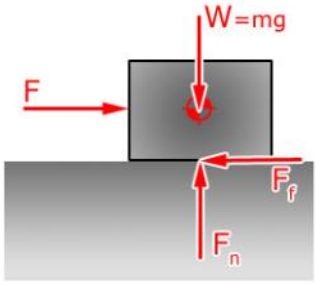
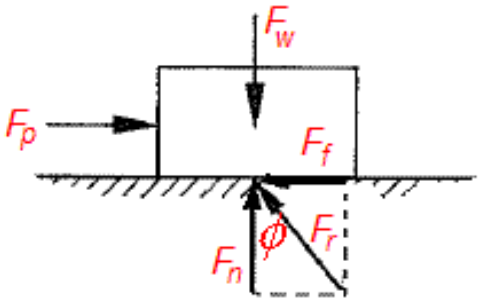
Q4: (cont) A block of mass 2.1 kg rests on a horizontal table. The coefficient of friction is 0.2. What horizontal force F will start the block moving?

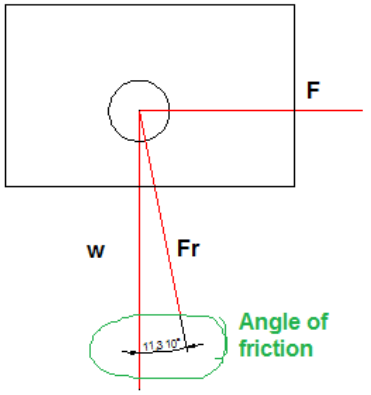


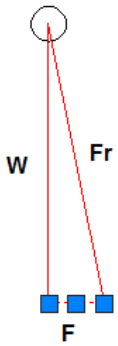
$$F_f = \mu F_n$$

Mathematically:
Coeff = 0.2, mass = 2.1
Fn = 2.1*9.81 = 20.601 N
Ff = 0.2 * Fn = 0.2 * 20.601 = 4.1202 N

Graphically;
Angle of friction = atan (coeff)
= atan(0.2) = 11.31 degs
Convert mass to N: 2.1*9.81 = 20.601 N







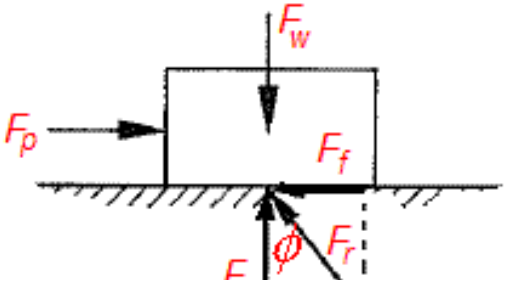
Measured on CAD
Pushing Force = 4.1202N

End Z	0
Delta X	4.1202
Delta Y	0
Delta Z	0
Length	4.1202
Angle	0

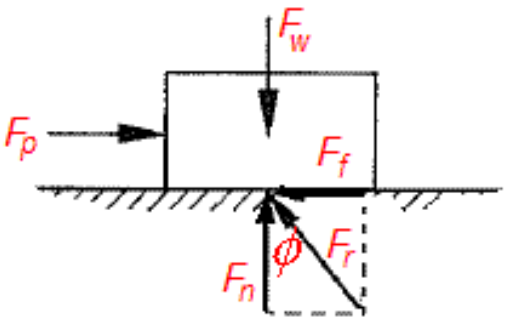
Q6: It took a force of F=108 N to get this block moving. The coefficient of friction is 0.5. What was the mass of the block?

$$F_f = \mu F_n$$

Mathematically:
Coeff = 0.5, mass = ?, Force Ff= 108N
Fn = Ff/coeff = 108/0.5 = 216 N
So mass = 216/9.81 = 22.0183 kg

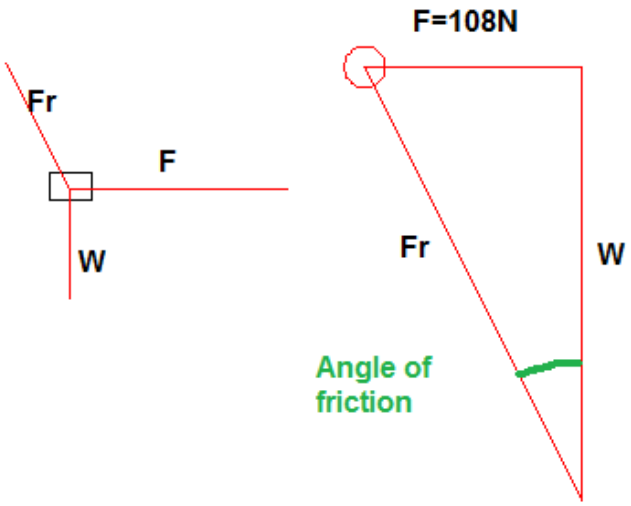


$$F_f = \mu F_n$$



Mathematically:
Coeff = 0.5, mass = ?, Force Ff= 108N
Fn = Ff/coeff = 108/0.5 = 216 N
So mass = 216/9.81 = 22.0183 kg

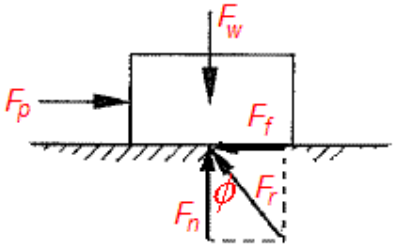
Graphically;
Angle of friction = atan (coeff)
= atan(0.5) = 26.565 degs
360 deg notation (90+26.565) = 116.565 degs



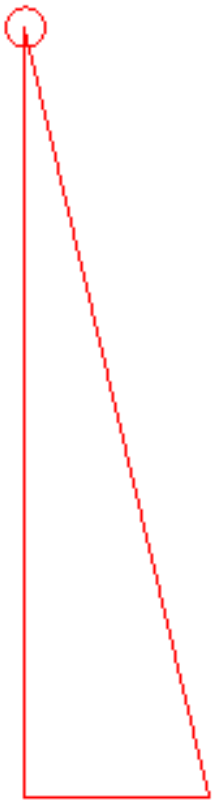
From CAD, weight force
Fn = 216.0005N
So mass = 216.0005/9.81
=22.0184 kg

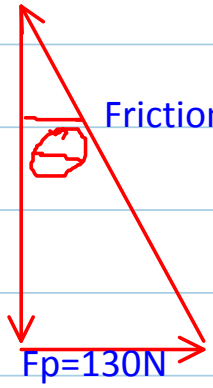
Q7: It took a force of F=130 N to get this 55 kg block moving. What is the coefficient of friction?

Mathematically:
Coeff = ?, mass = 55kg, Force Ff= 130N
Fn = 55 *9.81 = 539.55 N
Coeff = Ff/Fn = 130 / 539.55 = 0.2409



Graphically;
Solve using CAD, but find
The angle last...





Angle of friction force is
103.547 degs (in 360 notation)
So angle of friction =
103.547 -90 = 13.547 degs
So coeff = tan(13.547)
= 0.24095

Friction questions

Tuesday, 6 March 2012
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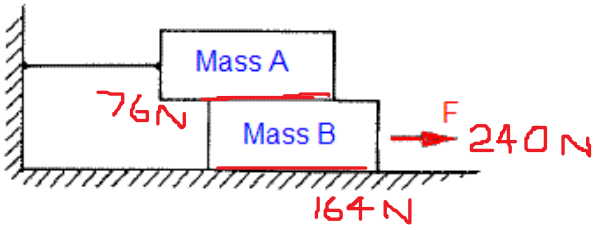
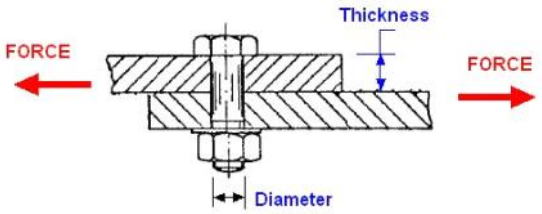
Q10: Block A=31 kg, and Block B=36 kg. The coefficient of friction between all surfaces is 0.25. What force F will make block B slide?



$$F_f = \mu F_n$$

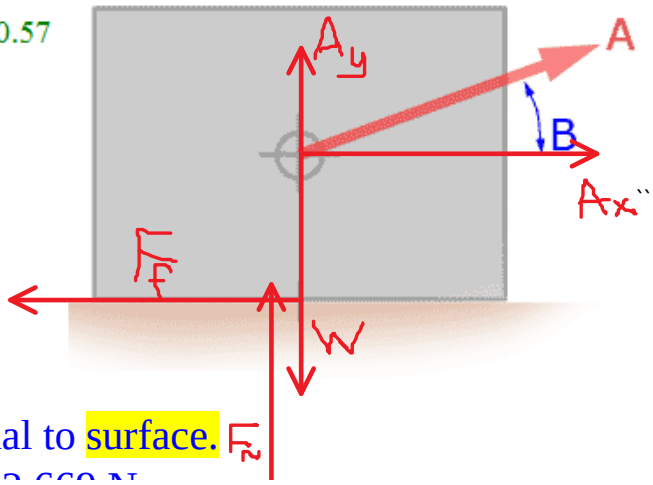
2 surfaces!
Top surface:
Ff = μFn = 0.25*(31*9.81) = 76.0275 N
Bottom surface:
Ff = μFn = 0.25*((31+36)*9.81) = 164.3175 N
Total Force = 76.0275 + 164.3175 = 240.345 N

Q11: This joint relies only on friction. FORCE=1.17 kN and coefficient of friction between plates is 0.28. What tension is needed in the bolt?



Ff = μFn
Fn = Ff/μ
= 1170/0.28
= 4178.5714 N

Q13: Force A=3220 N, angle B=54 degs, mass is 0.57 tonnes. What is the coefficient of friction?



Get Components - Parallel and Normal to surface.

Get Components - Parallel and Normal to surface.

Ax = A cos(θ) = 3220*cos(54) = 1892.669 N

Ay = A sin(θ) = 3220*sin(54) = 2605.035 N

W = mg = 570 * 9.81 = 5591.7 N

$$F_f = \mu F_n$$

Need the NORMAL FORCE!

F_n = W-Ay = 5591.7 - 2605.035 = 2986.665 N

$F_f = \mu F_n$, so $\mu = F_f / F_n$

The friction force is the parallel force...

F_f = 1892.669 N

So, $\mu = F_f / F_n$ = 1892.669 / 2986.665 = 0.6337 (No units)

Friction Inclined

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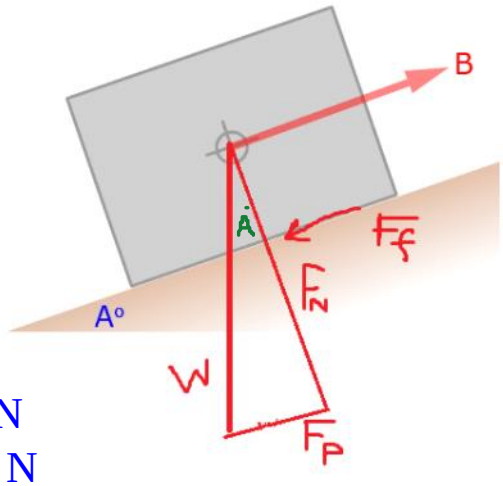
Q20: Incline angle A=32 degs, mass=283 kg. Coefficient of friction=0.19. What Force B is needed to pull it up the ramp?



W = 283*9.81 = 2776.23 N

Components WRT surface:

Fp = Wsin(θ) = 2776.23 * sin(32) = 1471.178 N

Fn = Wcos(θ) = 2776.23 * cos(32) = 2354.377 N

Ff = μFn = 0.19 * 2354.377 = 447.3316 N

Force balance in the parallel axis...

Fb = Fp+Ff

= 1471.178 + 447.3316 = 1918.5096 N

Ladder question

Tuesday, 5 March 2013
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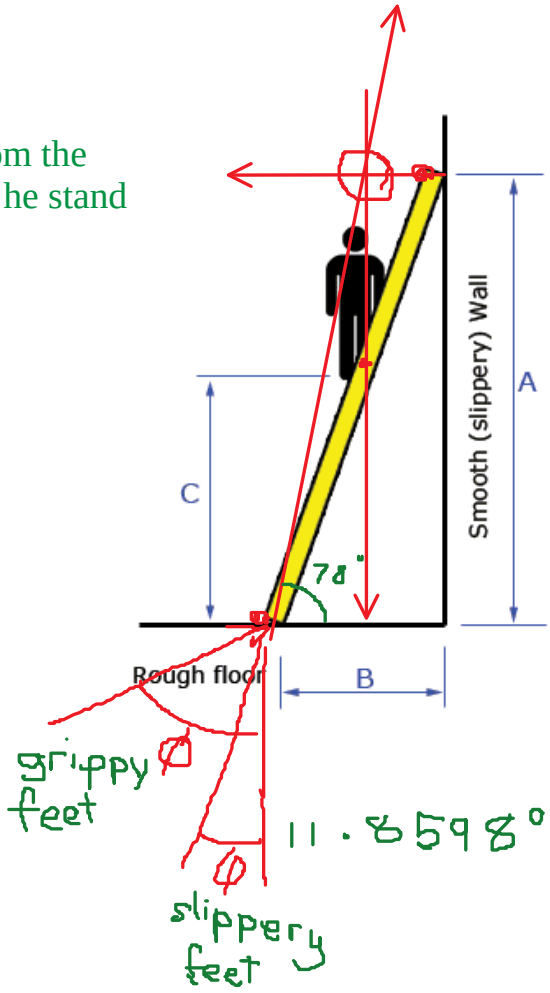
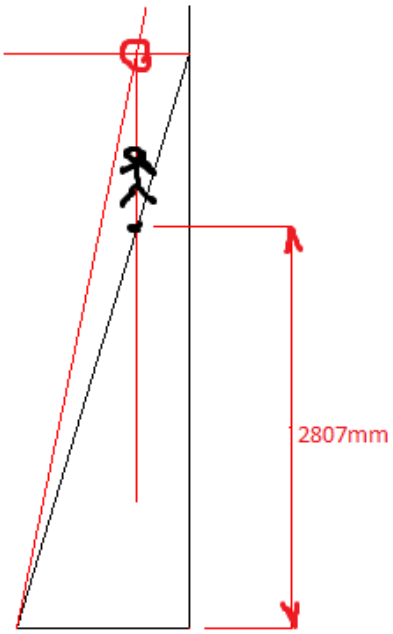
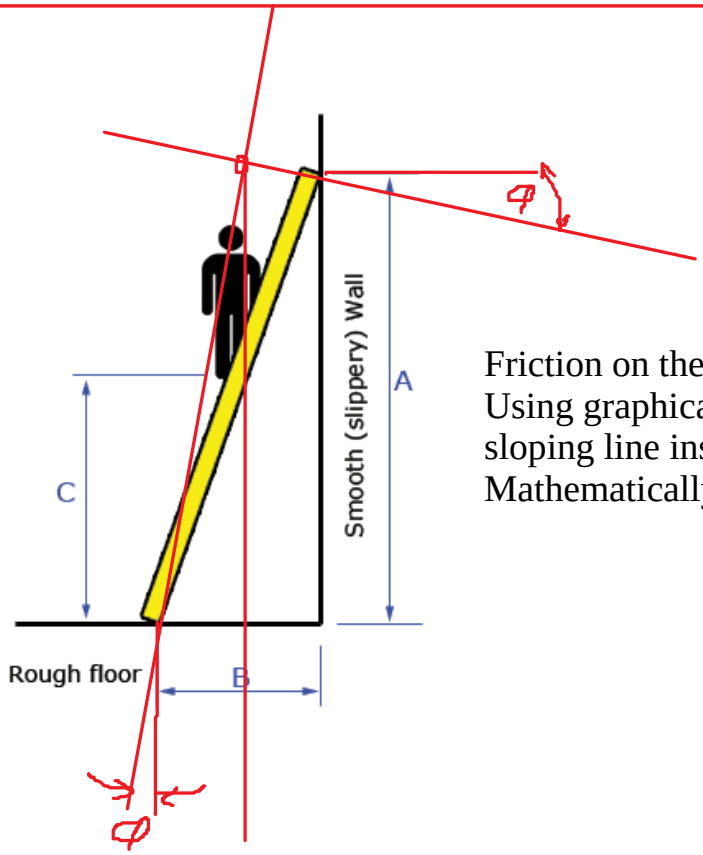
Q23: The foot of a 4.2m long ladder is B=1210 mm from the frictionless wall. If the COF is 0.21, how high (C) can he stand before the ladder will slip?



Angle of friction = atan(0.21) = 11.8598°
Force is at 90-11.8598 = 78.1402°
Now we have 3 forces of known direction;
1.Friction force at 79.7961°
2.Wall force at 180°
3.Weight of man at 270°
Solve using 3 force principle to find the position of the man, hence his height up the ladder.





Friction on the wall?
Using graphical method this is simply a sloping line instead of horizontal.
Mathematically, it is rather annoying.

Inclined everything

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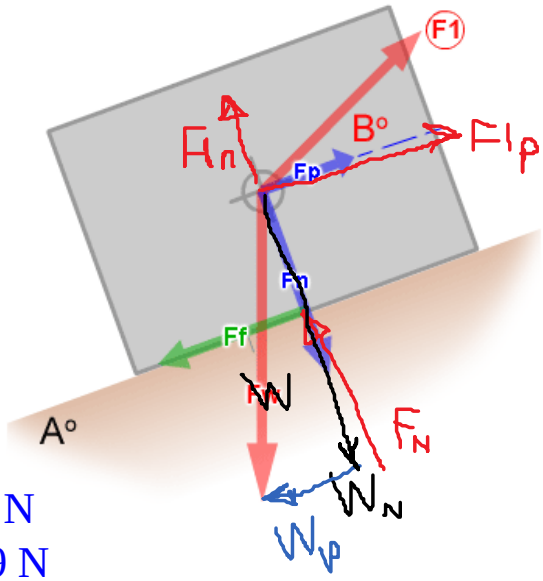
Q24: Incline angle A=34 degs, angle B=23 degs, mass=164 kg, F1=1030 N, coefficient of friction=0.6. What is the magnitude of normal force Fn?



W = 164*9.81 = 1608.84 N

1. Components compared to surface:

Wp = Wsin(θ) = 1608.84 * sin(34) = 899.6519 N
Wn = Wcos(θ) = 1608.84 * cos(34) = 1333.789 N
F1p = 1030*cos(23) = 948.12 N
F1n = 1030*sin(23) = 402.453 N

2. Normal (perp) Forces Balance

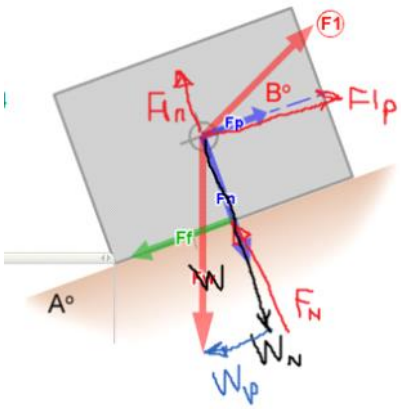
Fn + F1n -Wn
We want normal force (so we can do friction)
Fn = - F1n +Wn
= - 402.453+1333.789 = 931.336 N

3. Now do friction at interface

Ff = μFn = 0.6 * 931.336 = 558.8016 N

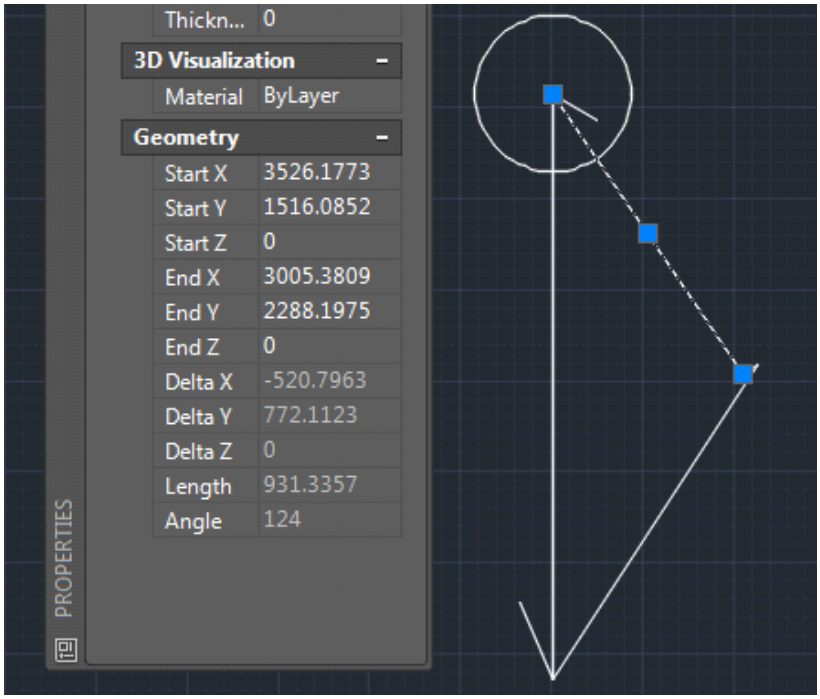
4. (EXTRA)
   What is the net parallel force?
   Force balance in the parallel...
   -Wp - Ff + F1p
   = -899.6519 - 558.8016 + 948.12 = -510.3335
   The force is too small to pull it up the hill when friction is fighting against it, so it will stay still.

Q24: Incline angle A=34 degs, angle B=23 degs, mass=164 kg, F1=1030 N, coefficient of friction=0.6. What is the magnitude of normal force Fn?



Solve this using CAD shall we?
W = 164*9.81 = 1608.84 N
Total force of surface TO the block:
932.5961 N
Friction of surface TO the block

48.4681 N down the slope
Normal force of surface TO the block
931.3357 N down the slope



Great Eastern

Tuesday, 26 March 2013
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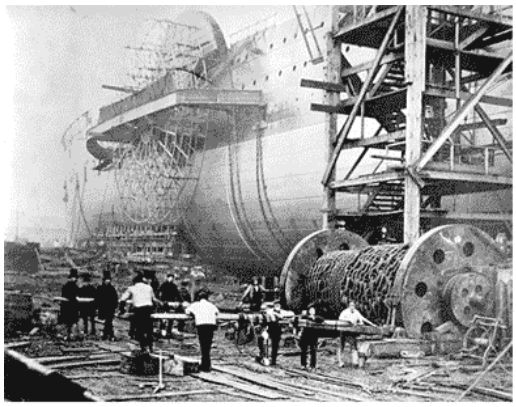
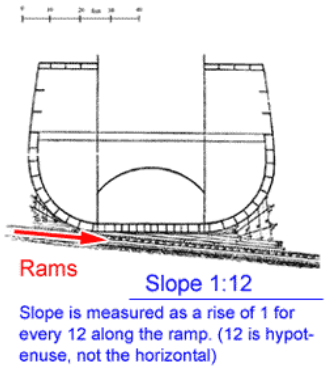
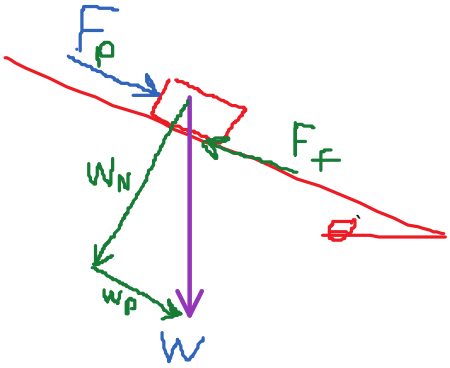




The launching of the Great Easton 1857.
The Great Eastern was 6 times larger than any other ship when it was built. It was meant to slide down the launch ways and into the water. It got stuck. Several months later a series of hydraulic rams finally got it moving.

Q19: The Great Eastern was 12030 tonnes, and the hydraulic rams applied 3470 tonnes of force down the ramp. What was the coefficient of friction?



Angle = asin(1/12) = 4.7802 °
Find Fn, then use Ff = μFn to get μ.
Components...
Wn = 12030*1000*9.81*cos(4.7802)
= 1.17603 E8 N
= 117603 kN
Wp = 12030*1000*9.81*sin(4.7802) = 9834.54 kN

Force balance in parallel direction;
"Sum of all forces in Parallel direction = 0"
Fp + Wp - Ff = 0
Ff = Fp + Wp = 3470*9.81 +9834.54 = 43875.24 kN

Now use Ff = μFn to get μ.
μ = Ff / Wn = 43875.24/117603 = 0.3731