# ECE 105 Quiz 6

## Thursday Tutorial

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At what minimum angle, θ, can the ladder lean without slipping?

**Thursday Group work:**

**1.** When the ladder is at the minimum angle, in which direction is the bottom of the ladder trying to slip?

1. It is not possible to tell before solving the question
2. It depends on the coefficient of friction
3. Left
4. Right

**2**. When the ladder is at the minimum angle, what is the direction of the frictional force from the wall on the ladder?

**a)** Down

**b)**  Up

**c)** It is not possible to tell before solving the question

**d)** It depends on the coefficient of friction on the ground and the wall.

**3**. How many forces act on the ladder?

**a)** 5

**b)** 6

**c)** 4

**d)** 7

**4**. How many torques act on the ladder?

**a)** 6

**b)** It depends on which pivot point you consider

**c)**  4

**d)** 5

**5**. For a pivot point at the top of the ladder, the torque due to gravity is

**a)** mg

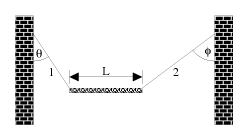
**b)** zero

**c)** clockwise

**d)** counterclockwise

## Friday Tutorial

**Individual (10 marks):** A bar of **non-uniform density**, length L and weighing 24.5 N is suspended horizontally at both ends with strings that are at angles of θ = 400 and ϕ = 550 as shown in the diagram. Find the bar’s center of mass, cm, in terms of L and the tension T1 and T2 in each of the two strings.



**Friday Group work:**

**1**  Why are the strings at different angles?

1. They are tied to the ceiling differently
2. The bar is not long enough
3. Unknown
4. The center of mass is not at the rod’s center

**2** Is there a net torque acting on the bar?

**a)** No

**b)** Yes

**c)** Depends on the location of the centre of mass

**d)** Depends on the axis of rotation

**3** Is there a net force acting on the bar?

**a)** Depends on the string angle

**b)** Yes

**c)** Depends on the axis of rotation

**d)** No

**4** Is there a torque caused by the bar’s weight?

**a)** No

**b)** Yes

**c**) Can’t be predicted

**d)** Depends on the axis of rotation chosen

**5** Is it possible to have a net torque if the net force is zero?

**a)** No

**b)** Yes

**c)** Only if the forces act through the center of rotation

**d)** Only if the moment arms are zero

# Solutions

## Thursday Tutorial

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At what minimum angle, θ, can the ladder lean without slipping?

- Take torque about ladders point of contact with the ground in order to get rid of two forces N and *f*.

Balancing torques: Στ= (*L* / 2)cosθ(*Mg*) 6cosθ (*mg*) - (*L*sinθ*Nw* - (*L* cosθ) *fw* = 0

[4(12) 6(40)]*g* cosθ- (8cosθ)μ*w Nw* - (8sinθ)*Nw* 0

[4(12) 6(40)]*g* cosθ- (8cosθ)μ*w Nw =*  (8sinθ)*Nw*

or **(288*g* - 8μ*w Nw*)cosθ(8sinθ)*Nw***(1)

we need to find Nw …. Balance forces:

Balancing forces: Σ*Fy* *Mg* *mg* - *fw* – *Nf* 0 ⇒ 52*g* - μ*w Nw* - *N f* 0 (2)

Σ*Fx* *Nw* - *ff* 0 ⇒ *Nw* *ff* μ*f N f or Nf = Nw/* μ*f* (3)

(3) ⇒ (2) becomes 52*g* - μ*wNw* - *Nw /* μ*f* 0 *or* ***Nw***52*g* / (0.45 1/ 0.55) **224.67 *N***

Using Nw from balancing forces in (1) gives …..

tanθ[288*g* - 8(0.45)(224.67)] / (8 224.67) 2013.6 / 1797.36 =1.1203 so **θ48.25*o***

## Friday Tutorial

Let cm be distant x1 and x2 from left/right hand side of bar respectively. Therefore the net torques and forces are:

Στcm = x1T1 cos40 – x2T2 cos55 = 0 (1)

ΣFy = T1 cos40 + T2 cos55 – mg = 0 (2)

ΣFx = T1 sin40 – T2 sin55 = 0 (3)

From (3) 0.643 T1 = 0.819 T2 or T1 = 1.274 T2

From (1)

x1 (1.274 T2)0.766 – x2T2 (0.574) = 0 or x1 = 0.588 x2 = 0.588(L – x1) and

**x1 = 0.370 L** and **x2 = 0.630 L**

From (2)

1.274T2 (0.766) + T2 (0.574) = mg or **T2** = mg/1.550 = **15.81 N** and **T1 = 20.14 N**