ROHININ COLLEGE OF ENGINEERING AND TECHNOLOGY
Approved by AICTE & Affliated to anna university
Accredited with A+ grade by NAAC
DEPARTMENT OF MECHANICAL ENGINEERING

NAME OF THE SUBJECT: ENGINEERING MECHANICS

SUBJECT CODE : ME3351

REGULATION 2021

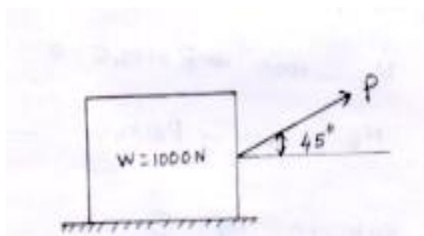
UNIT V: FRICTION

Friction:

Problem based on Friction:

1. A body weighting 1000N is lying on a horizontal plane. Determine the necessary force to move the body along the plane if the force is applied at angle of 45° to the horizontal with the coefficient of friction 0.24

Given:

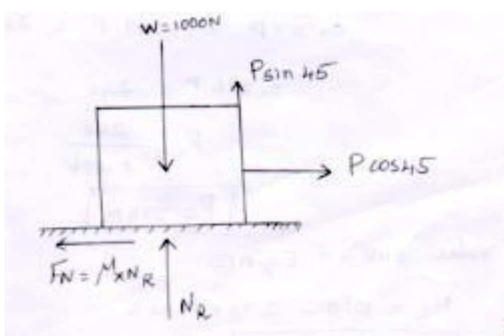


Coefficient of friction $\mu = 0.24$

Weight of body $w\ = 1000\ N$

To find

Soln



Sum of X Direction Force + ⟶ - ⟵

$\sum F_x = 0$

$Pcos45 - F_N = 0$

$Pcos45 - \mu \times N_R = 0$

$Pcos45 - 0.24 \times N_R = 0$ ---------------- (1)

↓

Sum of Y direction force $\uparrow$ + -

$\sum F_y = 0$

$N_R - 1000 + Psin45 = 0$

$N_R = 1000 + psin45 = 0$

N_R value sub in Eqn(1)

$Pcos45 - 0.24 \times [1000 - Psin45] = 0$

$Pcos45 - 240 + [Psin45 \times 0.24] = 0$

$0.707P + 0.169\, P = 240$

$0.876P = 240$

$$P = \frac{240}{0.876}$$

$P = 273N$

P value sub in eqn (2)

$N_R = 1000 - 273 \times sin45$

$N_R = 806.95\, N$

Problem: 2

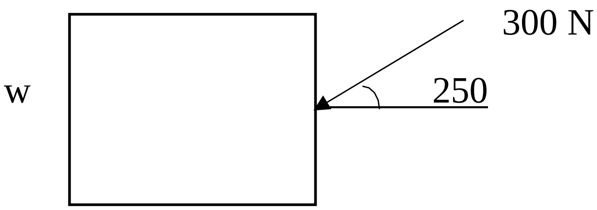
A pull of 250N inclined at 25° to the horizontal plane is required just to move a body kept on a rough horizontal plane. But the push required just to move the body is 300N. If the push is inclined at 25° to the horizontal. Find the weight of the body and the coefficient of friction b/w the body and the plane.

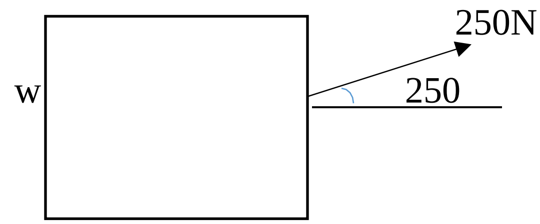
Given:

$P_1 = pull\ load = 250\ N\ at\ 25°$

$P_2 = push\ load = 300\ N\ at\ 25°$

To find



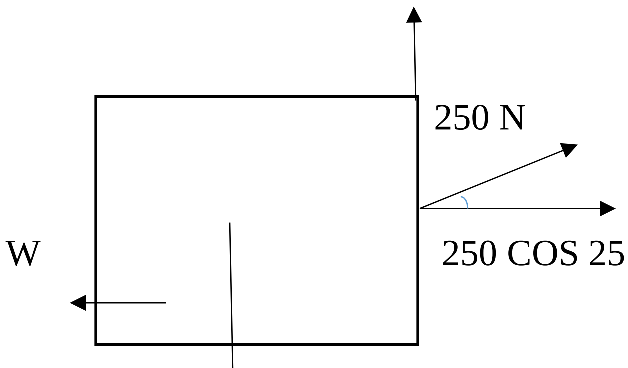


Weight and coefficient of friction

Soln

Case (i)

Free body diagram



Sum of x directional force + -

$\sum F_x = 0$

$250 \cos 25° - F_N = 0$

$250 \cos 25° - \mu \times N_{R1} = 0$

$226.57 - \mu \times N_{R1} = 0$

$-\mu \times N_{R1} = -226.57$

$\mu \times N_{R1} = 226.57$------------------- (1)

Sum of Y directional force - +

$\sum F_y = 0$

$N_{R1} - W + 250 \, sin25 = 0$

$N_{R1} = W - 250 sin25$

$N_{R1} = W - 105.65$----------------- (2)

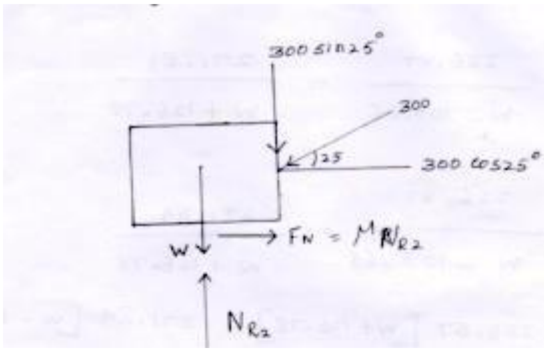
Sub eqn (1), from eqn (1)

$\mu N_{R1} = 226.57$

$\mu = \frac{226.57}{N_{R1}}$

$\mu = \frac{226.57}{W-105.65}$ --------------- (3)

Case (2) Free body diagram



Sum of X Directional force $\sum F_x = 0$

$F_N - 300cos25° = 0$

$\mu N_{R2} = 300cos25°°$

$\mu N_{R2} = 271.89N$------------- (4)

Sum of vertical force[Y direction] $\sum F_y = 0$

$N_{R2} - W - 300sin25° = 0$

$N_{R2} = W + 300sin25°$

$N_{R2} = W + 126.78$

N_{R2} value sub in Eqn (4)

$\mu N_{R2} = 271.89$

$\mu = \frac{271.89}{N_{R2}}$

$\mu = \frac{271.89}{W+126.78}$ ----------- (5)

Eqn (3) =Eqn (5)

$$\frac{226.57}{W - 105.65} = \frac{271.89}{W + 126.78}$$

$226.57[W + 126.78] = 271.89[W - 105.65]$

$226.57W + 28.72 \times 10^3 = 271.89W - 28.72 \times 10^3$

$226.57W - 271.89W = -28.72 \times 10^3 - 28.72 \times 10^3$

$-45.32W = -57.44 \times 10^3$

$$W = \frac{57.44 \times 10^3}{45.32}$$

$W = 1267.43N$

W value sub in eqn (3)

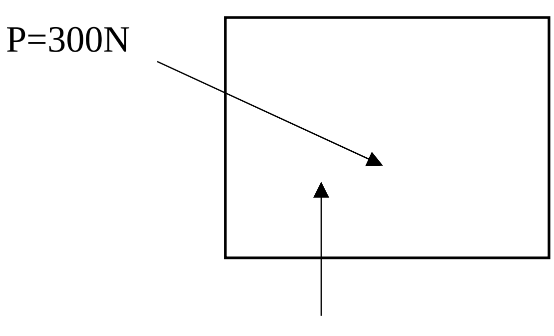
$$\mu = \frac{226.57}{W - 105.65}$$

$$\mu = \frac{226.57}{1267.43 - 105.65}$$

$\mu = 0.195$

Problem 3

Calculate the static coefficient of friction μ_sb/w the block shown in fig having a mass of 75kg and the surface. Also find the magnitude and direction of the friction force if the force P applied is inched at 45° to the horizontal and $\mu_s = 0.30$



Given:

Weight= $75\ kg = 75 \times 9.81 = 735.75N$

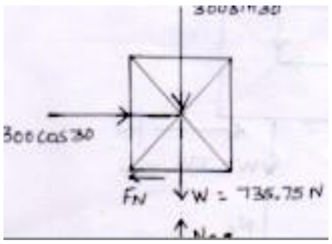
To find

Case (i) Coefficient of friction μ_s

Case (ii) Frictional force 'F_N', Direction Ø

Soln

Case (i) free body diagram



Sum of all the X direction force $\sum F_x = 0$

$300\cos 30 - F_N = 0$

$300\cos 30 - \mu N_R = 0$

$\mu N_R = -300cos30$

$\mu N_R = 259.8$--------------- (1)

Sum of all the Y direction force $\sum F_y = 0$

$-300\sin 30 - 735.75 + N_R = 0$

$N_R = 300sin30 + 735.75$

$N_R = 885.75\ N$

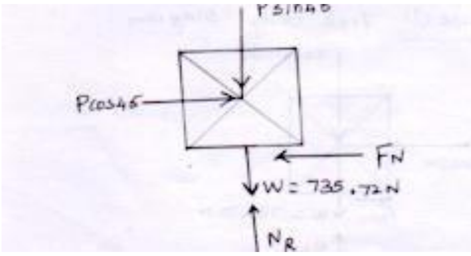
N_R value sub in eqn(i)

$\mu N_R = 259.8$

$$\mu = \frac{259.8}{N_R} = \frac{259.8}{885.75}$$

$\mu = 0.29$

Case (ii) free body diagram



Sum of all the horizontal force [X direction] $\sum F_x = 0$

$P\cos 45 - F_N = 0$

$-F_N = -P\cos 45$

$F_N = P\cos 45$

$\mu N_R = p\ cos45$

$N_R = \frac{pcos45}{\mu} = \frac{pcos45}{0.3}$

$N_R = 2.35p$

Sum of all the Direction force $\sum F_y = 0$

$-p\ sin45 - 732.72 + N_R = 0$

$-p \times 0.7 - 735.72 + 2.35p = 0$

$-0.7p + 2.35p = 735.72$

$1.64p = 735.72$

$p = \frac{735.72}{1.64}$

$p = 447.81N$

$N_R = 2.35p$

$N_R = 2.35 \times 447.81$

$N_R = 1052.37N$

$F_N = \mu \times R = 0.3 \times 1052.37$

F_N=315.71N

Direction Ø

$\emptyset = tan^{-1}\,[\frac{}{N_R}]$

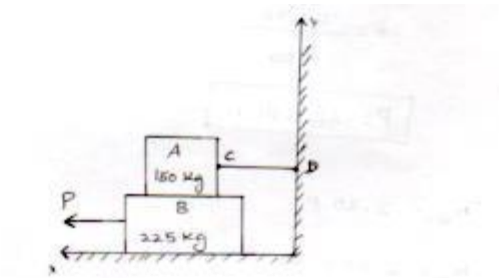
$\emptyset = tan^{-1}\,[\frac{315.71}{1052.37}]$

$\emptyset = 16°41'$

Problem 4:

Determine the smallest force P required to move the block B shown n fig below (i) block A is restrained by cable CD as shown in fig. (ii) Cable CD is removed. Take

$\mu_s = 0.30$ *and* $\mu_k = 0.25$



Given:

$W_A = 150kg = 150 \times 9.81 = 1471.5N$

$W_B = 225kg = 225 \times 9.81 = 2207.25N$

$\mu_s = 0.3$

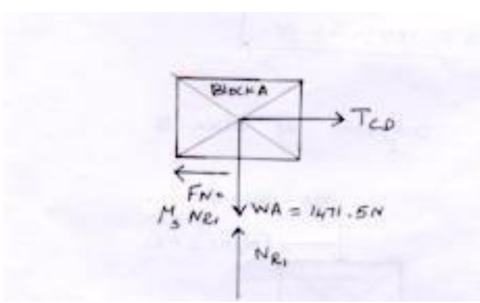
$\mu_k = 0.25$

To find

Force P

Soln

Block A is restrained by cable CD



Sum of X direction force $\sum = 0$

$T_{CD} - F_N = 0$

$T_{CD} - \mu_s N_{R1} = 0$

$T_{CD} = \mu_s N_{R1}$

$T_{CD} = 0.3 N_{R1}$------------- (1)

Sum of vertical [Y direction force] $\sum F_y = 0$

$N_{R1} - W_A = 0$

$N_{R1} = W_A$

$N_{R1} = 1471.5N$

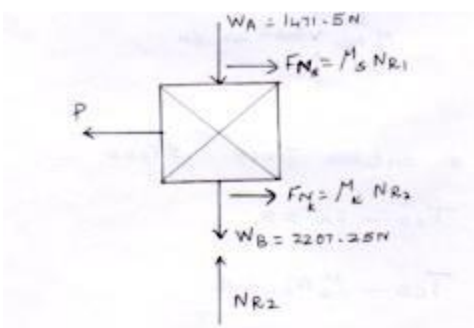
N_{R1} value sub in eqn(i)

$T_{CD} = 0.3\ R_1$

$T_{CD} = 0.3 \times 1471.3$

$T_{CD} = 441.45\ N$

Free body diagram of block B



Sum of X direction force

$F_{N_s} + F_{N_k} - p = 0$

$\mu_s N_{R1} + \mu_k N_{R2} - p = 0$

$p = \mu_s N_{R1} + \mu_k N_{R2}$-------- (1)

Sum of Y direction force

$-1471.5 - 2207.25 + N_{R2} = 0$

$N_{R2} = 1471.5 + 2207.25$

$N_{R2} = 3678.75N$

N_{R2} value sub in Eqn (1)

$p = \mu_s N_{R1} + \mu_k N_{R2}$

$p = 0.3 \times 1471.5 + 0.25 \times 3678.75$

$p = 1361.14\ N$

(i) Cable CD is removed

Both block is removed

Both the block will consider as a single body

$p = F_N$

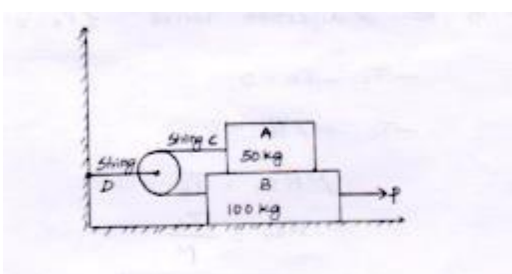
$p = \mu_k N_{R2} = 0.25 \times 3678.75$

$p = 919.68N$

Problem-6

Two blocks A and B of mass 5o kg and 10 kg respectively are connected by a string c which passes through a frictionless pulley connected with the fixed wall by another string D as shown in fig. Find the force P required to pull the block B. also find the tension in the string D.

Take coefficient of friction at all contact surface as 0.3°



Given:

Weight of block A $W_A = 50kg = 50 \times 9.81 = 490.5N$

Weight of block B $W_B = 100kg = 100 \times 9.81 = 981N$

Coefficient of friction$\mu = 0.3$

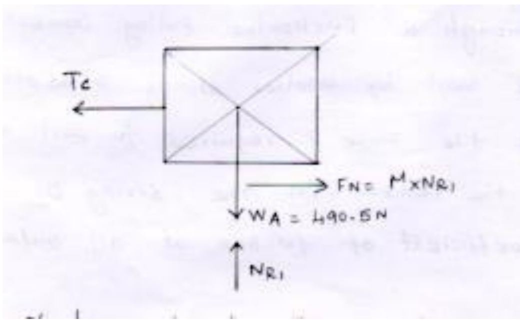
To find

(i) Force P

(ii) Tension in string T_D

Soln

Free body diagram of block A



Sum of x direction forces $\sum F_x = 0$

$-T_c$-$F_N = 0$

$-T_c + \mu N_{R1} = 0$

$\mu N_{R1} = T_c$

$N_{R1} = \dfrac{T_c}{\mu}$

$N_{R1} = \frac{T_c}{0.3}$---------- (1)

Sum of Y direction force $\sum F_Y = 0$

$-W_A + N_{R1} = 0$

$N_{R1} = W_A$

$N_{R1} = 490.5\ N$

N_{R1} value sub in Eqn (1)

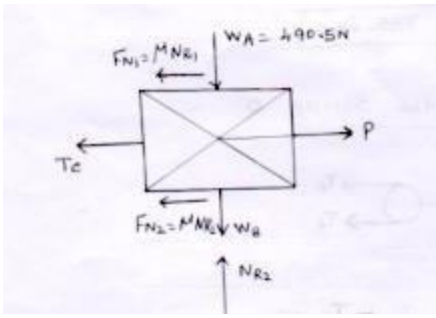
$N_{R1} = \dfrac{T_c}{0.3}$

$490.5 = \dfrac{T_c}{0.3}$

$T_c = 147.15\ N$

Consider block B

free body diagram



Sum of X direction force$\sum F_x = 0$

$p - T_c - F_{N1} - F_{N2} = 0$

$p - \mu N_{R1} + \mu N_{R2} = 0$

$p - 147.15 - 0.3 \times 490.15 - 0.3 \times N_{R2} = 0$

$p - 147.15 - 147.04 - 0.3 \times N_{R2} = 0$

$p - 294.19 - 0.3N_{R2} = 0$

$p = 294.19 - 0.3N_{R2} = 0$

$P = 294.19 + N_{R2}$------------- (2)

Sum of Y direction force $\sum F_Y = 0$

$N_{R2} - W_B - W_A = 0$

$N_{R2} - 981 - 490.5 = 0$

$N_{R2} = 1471.5N$

N_{R2} value sub in eqn(2)

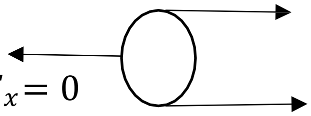
$p = 294.19 + 0.3N_{R2}$

$p = 294.19 + 0.3 \times 1471.5$

$p = 735.64N$

Tension in the string D:

T_D T_C



$\sum F_x = 0$

$T_c + T_c - T_D = 0$

$2T_c - T_D = 0$

$2 \times 147.15 - T_D = 0$

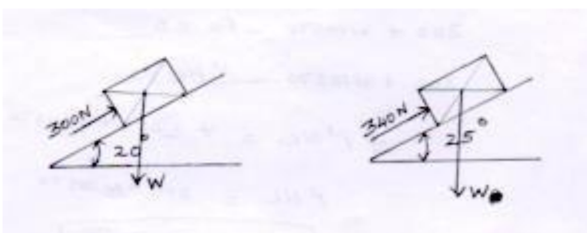
$294.3 - T_D = 0$

$-T_D = -294.3$

$T_D = 294.3N$

Problem -7

A force of 300 n is required just to move a block up a plane inclined at 20°.To the horizontal, the force being applied parallel to the plane shown in fig. if the inclination of the plane is increased to 25°, the force required just to move the block up is 340 N, [the force is acting parallel to the plane]. Determine the weight of the block and coefficient of friction.



Given:

Case (i)

Weight of body w=?

Force on body P= 300 N at 20°inclined on plane horizontal

Case (ii)

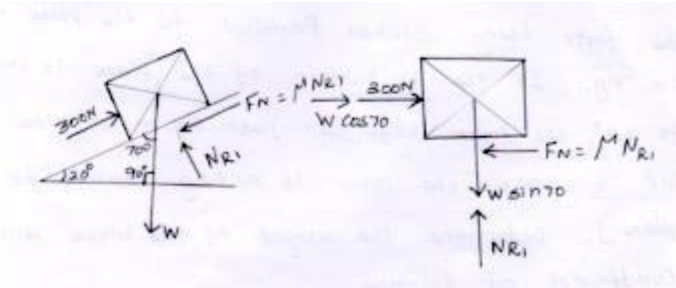
Force on body P= 340 N at 25°

To find:

Weight of body & coefficient of friction

Soln:

Case (i) free body diagram



Sum of X directional force $\sum F_X = 0$

$300 + wcos70 - F_N = 0$

$300 + wcos70 - \mu N_{R1} = 0$

$-N_{R1} = -[300 + wcos70]$

$\mu N_{R1} = 300 + w\cos 70$

$\mu = \frac{300+wcos70}{N_{R1}}$--------- (1)

Sum of all Y direction force $\sum = 0$

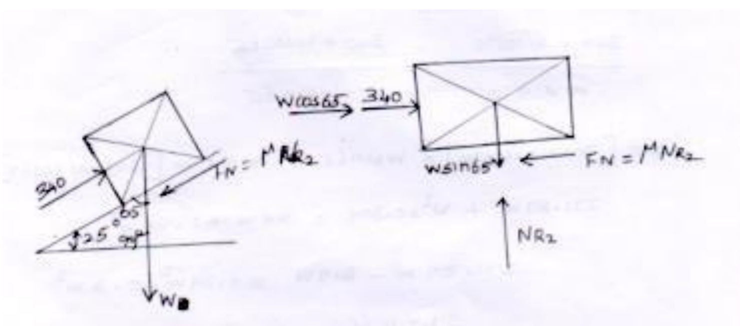
$N_{R1} - wsin70 = 0$

$N_{R1} = wsin70$------------ (2)

N_{R1} value sub in eqn (1)

$\mu = \frac{300+wcos70}{wsin70}$--------- (3)

Case (ii) consider block 2



Sum of all the X direction force $\sum F_X = 0$

$340 + w\cos 65 - F_N = 0$

$340 + wcos\ 65 - \mu N_{R2} = 0$

$-\mu N_{R2} = -[340 + wcos65]$

$\mu = \frac{340+wcos65}{N_{R2}}$--------- (4)

Sum of all the Y direction force $\sum F_Y = 0$

$N_{R2} - wsin65 = 0$

$N_{R2} = wsin65$-------------- (5)

Eqn (5) sub in eqn (4)

$\mu = \frac{340+w\cos 65}{w\sin 65}$------------- (6)

Eqn(3) =eqn (6)

$$\frac{300 + wcos70}{wsin70} = \frac{340 + w\cos 65}{w\sin 65}$$

$[300 + wcos70] \times wsin65 = wsin70[340 + w\ cos65]$

$271.89w + w^2 \times 0.309 = 319w + 0.39w^2$

$271.86w - 319w = 0.39w^2 - 0.3w^2$

$-47.11\ w = 0.09w^2$

$-47.11\ w = 0.09w$

$$w = \frac{-47.11}{0.09}$$

ans $w = -523.47\ N$

w value sub in eqn(3)

$$\mu = \frac{300 + wcos70}{wsin70}$$

$$\mu = \frac{300 + (-523.47)s70}{(-523.47)sin70}$$

Ans $\mu = -0.24$

Problem 8

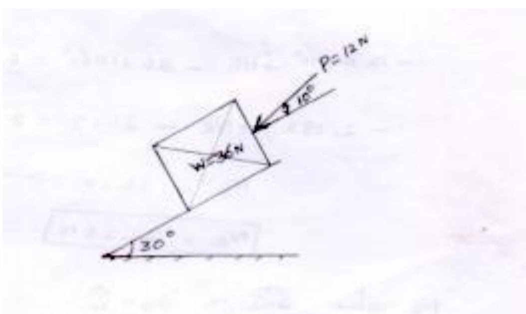
A block weighting 360 n is resting on a rough inclined plane having an inclination of 30°. A force of 12 N is applied at an angle of 10°up and the block is just on the point of moving down the plane. Determine the coefficient of friction

Given:

Block weight w=36 N

Inclination of the plane $\emptyset = 30°$

Force on block P=12 N at 10°

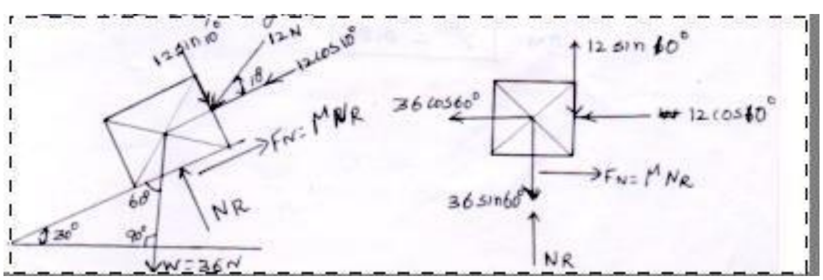


To find

Coefficient of frictionμ

Soln:

Free body diagram



Sum of X direction force $\sum F_X = 0$

$-12\ cos10 - 36cos60 + F_N$=0

$-11.87 - 18 + \mu N_R = 0$

$-29.87 + \mu N_R = 0$

$\mu N_R = 29.87$

$\mu = \frac{29.87}{N_R}$------ (1)

Sum of all the Y direction force $\sum F_y = 0$

$-12\ sin 10° + N_R - 36\ sin 60° = 0$

$-2.083 + N_R - 31.17 = 0$

$N_R - 33.25 = 0$

$N_R = 33.25\ N$

N_R value sub in Eqn (1)

$\mu = \frac{29.87}{N_R} = \frac{29.87}{33.25}$

$ans\ \mu = 0.89$