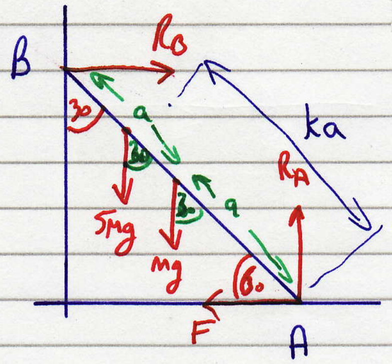
Rigid Body PPQ's

M/56

① **June 01 Q3**



when man @ greatest possible distance from A, ladder is in limiting equilibrium

$\therefore \quad F = \mu R_A \quad$ — ①

$\Sigma F_x: \; R_B - F = 0 \quad$ — ② B1 B1

$\Sigma F_y: \; R_A - 5Mg - Mg = 0 \quad$ — ③ B1

$\Sigma G_A: a \times Mg \sin 30 + ka \times 5Mg \sin 30 - 2a \times R_B \sin 60 = 0 \quad$ — ④ M1 A1 A1 A1

From ③ $R_A = 6Mg$

in ① $F = \mu R_A = 0.5 \times 6Mg = 3Mg$

in ② $R_B = F = 3Mg$

in ④ $Mga \frac{1}{2} + 5kaMg \frac{1}{2} - 2a \times 3Mg \times \frac{\sqrt{3}}{2} = 0$ M1

$\frac{1}{2} + \frac{5k \times 1}{2} - 3\sqrt{3} = 0$

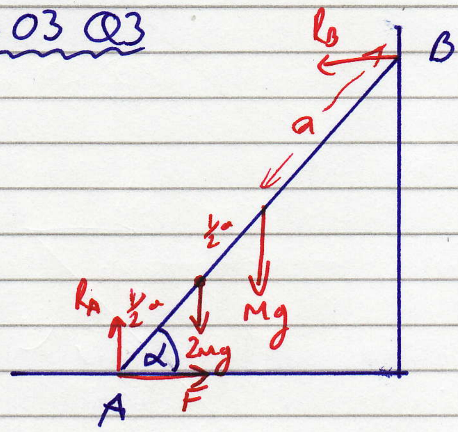
$1 + 5k = 6\sqrt{3}$

$5k = 6\sqrt{3} - 1$

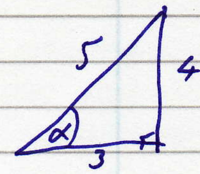
$k = \frac{6\sqrt{3} - 1}{5} = 1.88$ A1 A1

M/9

② Jan 03 Q3



$\tan\alpha = \frac{4}{3}$



ΣF_x: $F - R_B = 0$ —① B1

ΣF_y: $R_A - 2mg - mg = 0$ —② B1

$F = \mu R_A$ —③

M1 A1 A1 A1 ΣG_A: $2a \times R_B \sin\alpha - \frac{1}{2}a \times 2mg \sin(90-\alpha) - a \times mg \sin(90-\alpha) = 0$

$2R_B \sin\alpha - mg\cos\alpha - mg\cos\alpha = 0$

$2R_B \sin\alpha - 2mg\cos\alpha = 0$

$\div \cos\alpha$

$R_B \tan\alpha = mg$

but $\tan\alpha = \frac{4}{3}$ $\frac{4}{3}R_B = mg$ $R_B = \frac{3mg}{4}$ B1

From ① $F = R_B = \frac{3mg}{4}$

From ② $R_A = 3mg$

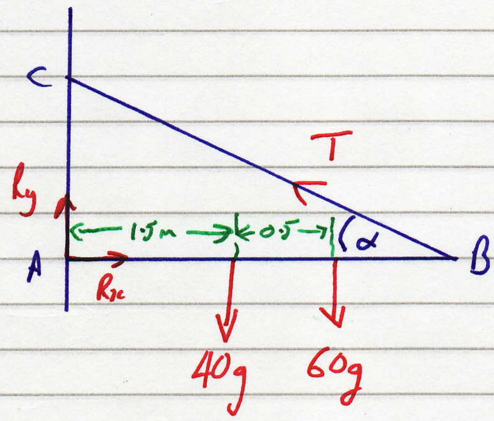
In ③ $\frac{3mg}{4} = \mu 3mg$ M1

$\mu = \frac{1}{4}$ A1 This will give limiting equilibrium when child a distance of $\frac{1}{2}a$ up ladder.

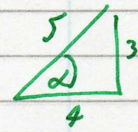
A lower value of μ will have triggered limiting equilibrium further down ladder, ie it would have slipped before child reached C.

$\frac{11}{9}$

(3) June 03 Q4



$\tan\alpha = \frac{3}{4}$



$\sin\alpha = \frac{3}{5}$

$\cos\alpha = \frac{4}{5}$

$\Sigma F_x \quad R_x - T\cos\alpha = 0$ — (1)

$\Sigma F_y \quad R_y - 40g - 60g + T\sin\alpha = 0$ — (2)

$\Sigma G_A \quad 3T\sin\alpha - 1.5\times 40g - 2\times 60g = 0$ — (3) M1 A1 A1 A1)

(a) $3T\sin\alpha = 180g$

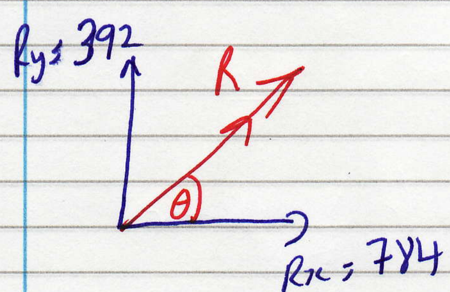
$3T.\frac{3}{5} = 180g$

$T = 180g \times \frac{5}{9} = 980\text{ N}$ A1

(b) From (1) $R_x = 980 \times \frac{4}{5} = 784$ M1 A1

From (2) $R_y = 100g - T\sin\alpha$

$= 980 - 980\times\frac{3}{5} = 392\text{ N}$ M1 A1



$R = \sqrt{392^2 + 784^2} = 876.5\text{ N}$ M1 A1

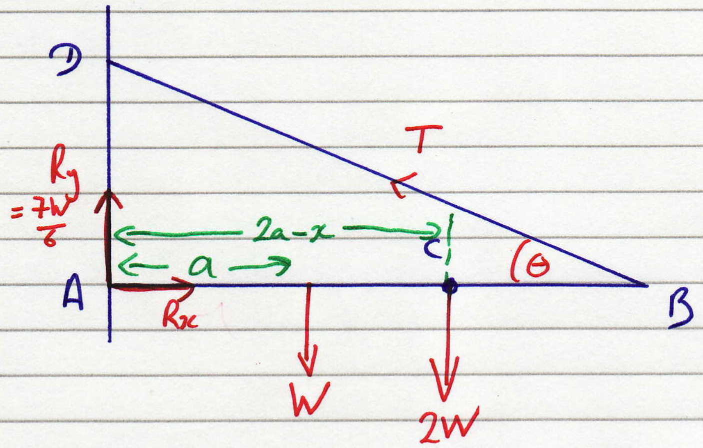
$\theta = \tan^{-1}\left(\frac{392}{784}\right) = 26.6^\circ$

(c) Only mass of load acting @ D. B1

11/12.

④ JAN 02 Q5

$\sin\theta = \frac{3}{5}$



(a) ΣG_A: $2a \times T\sin\theta - aW - (2a-x)2W = 0$ M1 A1 A1 A1

$2aT \times \frac{3}{5} - aW - 4aW + 2xW = 0$

$\frac{6aT}{5} = 5aW - 2xW$

$T = \frac{5(5a-2x)W}{6a}$ As required A1

(b) Σf_y: $R_y + T\sin\theta - W - 2W = 0$

$\frac{7W}{6} + \frac{5(5a-2x)W}{6a} \cdot \frac{3}{5} = 3W$ M1 A1

$\times 6a$

$7a + 3(5a-2x) = 18a$

$15a - 6x = 11a$

$6x = 4a$

$x = \frac{2a}{3}$ A1

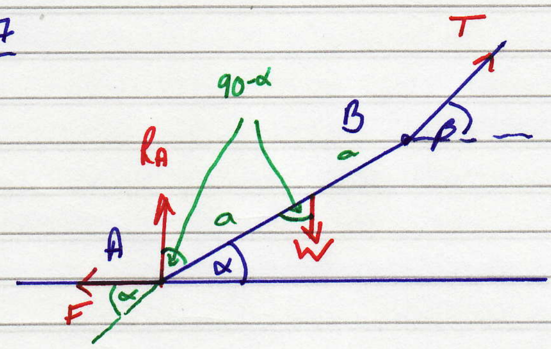
(c) Σf_x: $R_x - T\cos\theta = 0$ M1

$R_x = \frac{5(5a-2x)W}{6a} \times \frac{4}{5}$ A1 $= \frac{2W}{3a}(5a-2x)$

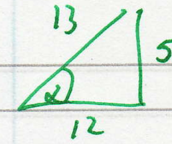
$= \frac{2W}{3a}\left(5a - 2 \times \frac{2a}{3}\right)$ A1 $= \frac{2W}{3a}\left(\frac{11a}{3}\right) = \frac{22W}{9}$ A1

M 12

(5) June 02 Q7



$\tan\alpha = \frac{5}{12}$



$\sin\alpha = \frac{5}{13}$

$\cos\alpha = \frac{12}{13}$

~~ΣG_B: $a \times W\cos\alpha$ a $2a \times R_A$~~

(a) ΣG_B: $a \times W\sin(90-\alpha) - 2a \times R_A\sin(90-\alpha) - 2a \times F\sin\alpha = 0$

$W\cos\alpha - 2R_A\cos\alpha - 2F\sin\alpha = 0$ M1 A1 A1 A1

Now $F = \mu R_A = 0.6R_A$

A1

$W.\frac{12}{13} - 2R_A.\frac{12}{13} - 2 \times 0.6R_A.\frac{5}{13} = 0$

×13

$12W - 24R_A - 6R_A = 0$

$30R_A = 12W$

$R_A = \frac{12}{30}W = \frac{2}{5}W$ A1 As required.

(b) ΣF_y: $R_A + T\sin\beta - W = 0$

$\frac{2}{5}W + T\sin\beta = W$

$T\sin\beta = \frac{3W}{5}$ — (1) M1 A1

ΣF_x: $T\cos\beta - F = 0$

$T\cos\beta = F$

but $F = 0.6R_A = 0.6 \times \frac{2}{5}W = 0.24W$

$\therefore T\cos\beta = 0.24W$ — (2) M1 A1

(1) ÷ (2) $\frac{T\sin\beta}{T\cos\beta} = \frac{0.6W}{0.24W}$

$\tan\beta = 2.5$ $\beta = 68.2^\circ$ M1 A1.

5 (c) $T = kW$ in (2)

$kW\cos\beta = 0.24W$ M1

$k = \frac{0.24}{\cos(68.2)} = 0.65$ A1

M
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