M/48

M2 - Jan 2003

Q1 (a) $(3\mu + 5\mu + \lambda\mu)\begin{pmatrix}2\\k\end{pmatrix} = 3\mu\begin{pmatrix}4\\0\end{pmatrix} + 5\mu\begin{pmatrix}0\\-3\end{pmatrix} + \lambda\mu\begin{pmatrix}4\\2\end{pmatrix}$ M1 A1 A1 M1

$\begin{pmatrix}16+2\lambda\\8k+\lambda k\end{pmatrix} = \begin{pmatrix}12+4\lambda\\-15+2\lambda\end{pmatrix}$

$16+2\lambda = 12+4\lambda$ M1

$2\lambda = 4$

$\lambda = 2$ As required A1

(b) $8k+2k = -15+4$ A1

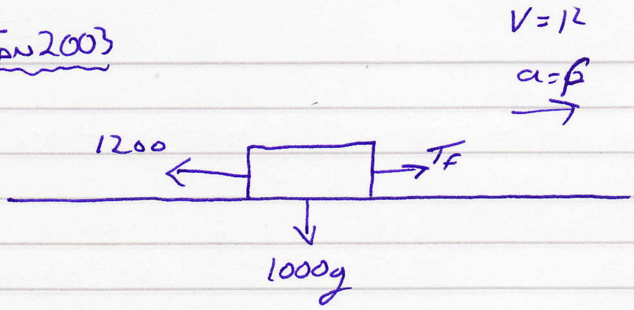
$10k = -11$

$k = \frac{-11}{10} = -1.1$ A1

M/7

M2 - JAN 2003

Q2



(a) $P = T_F \times V$

$24000 = T_F \times 12$

$T_F = \frac{24000}{12} = 2000\ N$ M1

N2L: $T_F - 1200 = 1000a$ M1 A1

$2000 - 1200 = 1000f$

$f = 0.8\ ms^{-2}$ A1

(b) Energy loss = wd v's resistances

$\frac{1}{2} \times 1000 \times 14^2 - 0 = 1200 \times d$ M1 A1

$98000 = 1200d$

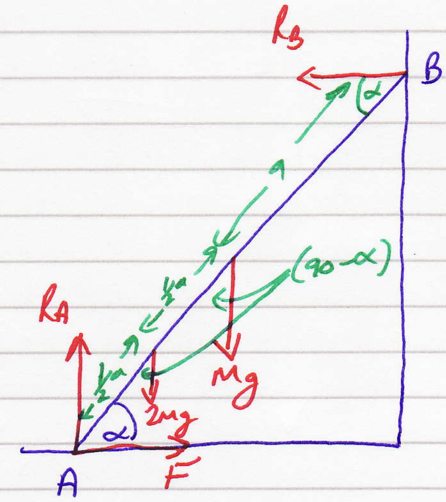
$d = 81\frac{2}{3}$ metres. A1

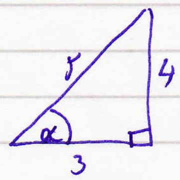
(c) Resistance to motion is likely to vary with speed B1

M/8

M2 - JAN 2003

Q3





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

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

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

To find least possible value of μ, ladder about to slide = limiting equilibrium

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

$\Sigma F_x : \quad F - R_B = 0 \quad$ — (2)

$\Sigma F_y : \quad R_A - 3Mg = 0 \quad$ — (3)

M1 A1 A1 A1 $\quad \Sigma G_A : \quad 2a \times R_B \sin\alpha - \frac{1}{2}a \times 2Mg \sin(90-\alpha) - a \times Mg \sin(90-\alpha) = 0$ ($\sin(90-\alpha) = \cos\alpha$)

$2 \times R_B \times \frac{4}{5} - Mg \times \frac{3}{5} - Mg \times \frac{3}{5} = 0$

$\times 5$

$8R_B - 6Mg = 0$

$R_B = \frac{6Mg}{8} = \frac{3}{4}Mg$

A1 $\quad \therefore$ in (2) $\quad F = \frac{3}{4}Mg$

A1 $\quad$ From (3) $\quad R_A = 3Mg$

M1 A1 $\quad$ in (1) $\quad \frac{3}{4}Mg = \mu 3Mg$

$\therefore$ ladder is on point of slipping when $\mu = \frac{1}{4}$

A1 $\quad$ So for ladder not to slip, $\mu \geq \frac{1}{4}$.

M/9

M2 - JAN 2003

Q4 (a) Let mass per $cm^2 = M$

From AE: $\left(48a^2M + \frac{1}{2} \times 6a \times 4aM\right)G = 48a^2M(4a) + 12a^2M\left(\frac{4}{3}a + 8a\right)$ M1 A1 A1

$60a^2MG = 192a^3M + 112a^3M$ A1

$60a^2MG = 304a^3M$

$G = \frac{76}{15}a$ = Distance from AE A1

Distance from BD $= 8a - \frac{76}{15}a = \frac{44}{15}a$ As required. A1

(b)

GB: $\frac{44}{15}a \times Mg = 4a \times \lambda Mg$ M1 A1

$\lambda = \frac{11}{15}$ A1

9/9