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(1)

M1 Jan 03 - Solutions

1. Before: P 2000kg, 10ms⁻¹; Q 2000kg

After: P 2000kg, Vms⁻¹; Q 2000kg, 5ms⁻¹

a) Cons. of mom. $10\times2000 = 2000V + 3000\times5$

$20000 = 2000V + 15000$

$5000 = 2000V$

$V = \frac{5}{2}\,ms^{-1}$

b) Impulse = Change in mom.

= mom. after − mom. before

$= 5\times3000 - 0 = 15000\,Ns$

2. 12N at α, θ, X N, 8N

a) Vertically $12\cos\alpha = 8$

$\cos\alpha = \frac{8}{12}$ $\quad \alpha = 48.2^\circ \Rightarrow \theta = 138.2^\circ$

b) Horizontally $X = 12\sin\alpha = 12\sin(48.18968)$

$= 8.94N$

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3. a) s: $u\ 6\underline{i}-27\underline{j}$, $v\ -14\underline{i}+21\underline{j}$, $a\ a$, $t\ 4$

$v = u + at$

$a = \frac{v-u}{t} = \frac{-20\underline{i}+48\underline{j}}{4}$

$= (-5\underline{i}+12\underline{j})\,ms^{-2}$

b) $\underline{F} = m\underline{a} = 0.4(-5\underline{i}+12\underline{j}) = -2\underline{i}+4.8\underline{j}$

$|\underline{F}| = \sqrt{(-2)^2+(4.8)^2} = 5.2N$

4. a) $\underline{p} = 10t\underline{j}$ km

$\underline{q} = 6\underline{i}+12\underline{j} + t(-8\underline{i}+6\underline{j}) = (6-8t)\underline{i}+(12+6t)\underline{j}$

b) $\overrightarrow{PQ} = \underline{q}-\underline{p}$

$= (6-8t)\underline{i}+(12+6t)\underline{j}-10t\underline{j}$

$= (6-8t)\underline{i}+(12-4t)\underline{j}$

when $t=3$ $\overrightarrow{PQ} = (6-24)\underline{i}+(12-12)\underline{j} = -18\underline{i}$

∴ dist P→Q = 18km

c) If Q is North of P $\underline{i}$ component = 0

∴ $6-8t=0$

$t = 6/8 = 0.75$ hrs

(3)

5. N, T, 20°, F, 30°, 1.5g, 30°, $\mu = 0.1$

Parallel to Plane: $T\cos20 - 1.5g\sin30 - F = 0$ ①

Perpendicular to Plane: $N + T\sin20 - 1.5g\cos30 = 0$ ②

from ② $N = 1.5g\cos30 - T\sin20$ and $F = \mu N$

sub in ① $T\cos20 - 1.5g\sin30 - \frac{1}{3}(1.5g\cos30 - T\sin20) = 0$

$T\cos20 + \frac{1}{3}T\sin20 - 1.5g\sin30 - \frac{1}{3}\times1.5g\cos30 = 0$

$T = \frac{1.5g\sin30 + 0.5g\cos30}{\cos20 + \frac{1}{3}\sin20} = 11.0N$

6. 0.5m, 1m, 0.5m, 1m; A, B, C, D; N, N; x; W; 120N

Resolve forces $3N = W + 120$ −①

A) $0.5\times2N - Wx - 1.5\times120 + 2N = 0$

$N - Wx - 180 + 2N = 0$

$3N - Wx - 180 = 0$ −②

(4)

From eqn ① $3N = W + 120$

sub in ② $W + 120 - Wx - 180 = 0$

$W(1-x) = 60$

$W = \frac{60}{1-x}$

b) $0 < x < 1$

7. At Greatest height

a) s: 25.6, u u, v 0, a −9.8, t x

$v^2 = u^2 + 2as$

$0 = u^2 + 2\times25.6\times-9.8$

$u^2 = 501.76$

$u = 22.4\,ms^{-1}$

b) When ball hits the ground

s −1.5, u 22.4, v x, a −9.8, t t

$s = ut + \frac{1}{2}at^2$

$-1.5 = 22.4t - 4.9t^2$

$4.9t^2 - 22.4t - 1.5 = 0$

$t = \frac{22.4 \pm \sqrt{(22.4)^2 - 4\times4.9\times-1.5}}{2\times4.9}$

$= \frac{22.4 \pm \sqrt{531.16}}{9.8} = 4.64_{s}$ or $-0.07s$

∴ T = 4.64s

(5)

c)

Resultant force = $0.6g - F$

Force = mass × acc.

$0.6g - F = 0.6a$

$a = \frac{0.6g - F}{0.6}$

s	~~1.25~~ 0.025	Initial velocity upon striking the ground in the final velocity from falling
u	u	
v	0	
a	$\frac{0.6g-F}{0.6}$	from b) $v = u + at$
t	x	$= 22.4 - 9.8 \times 4.64 = -23.07$

so $23.07 ms^{-1}$ downwards

$\therefore \quad v^2 = u^2 + 2as$

$0 = 23.07^2 + 2 \times \left(\frac{0.6g - F}{0.6}\right) \times 0.025$

$0 = 532.2249 + 0.05g - 0.08333F$

$F = \frac{532.2249 + 0.05g}{0.083333} = 6390\ N$ (3sf)

d) Air resistance.

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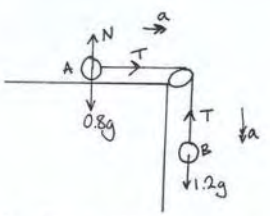
8.



a) For A Force = mass × acc.

$T = 0.8a$ (1)

For B $1.2g - T = 1.2a$ (2)

(1)+(2) $1.2g = 2a$

$a = 0.6g = 5.88 ms^{-2}$

sub in (1) $T = 0.8 \times 0.6g = 0.48g = 4.70\ N$

b)

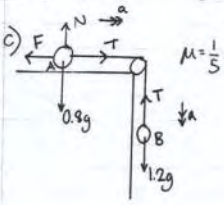
s	0.6
u	0
v	x
a	5.88
t	t

$s = ut + \frac{1}{2}at^2$

$0.6 = \frac{1}{2} \times 5.88 t^2$

$t = \sqrt{\frac{1.2}{5.88}} = 0.452s$

c)



For A

$T - F = 0.8a$

$T - \frac{1}{5} \times 0.8g = 0.8a \quad (F = \mu N)$

$T - 0.16g = 0.8a$ (1)

For B

$1.2g - T = 1.2a$ (2)

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(7)

(1)+(2) $1.2g - 0.16g = 2a$

$a = \frac{1.04g}{2} = 5.096 ms^{-2}$

s	0.6
u	0
v	x
a	5.096
t	t

$s = ut + \frac{1}{2}at^2$

$0.6 = \frac{1}{2} \times 5.096 \times t^2$

$t = \sqrt{\frac{1.2}{5.096}} = 0.485s$
