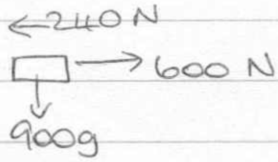
M1. June 2008.

1.



(i) using "F=ma"

$600 - 240 = 900a$

$\therefore a = \frac{360}{900} = 0.4$

$\therefore a = 0.4\ m/s^2$

(ii)
$u = 5$
$v = 9$
$a = 0.4$
$s = ?$
$t = ?$

$s = \frac{1}{2}(u+v)t$.

$v = u + at$

$\therefore 9 = 5 + 0.4t$

$\therefore 0.4t = 4$

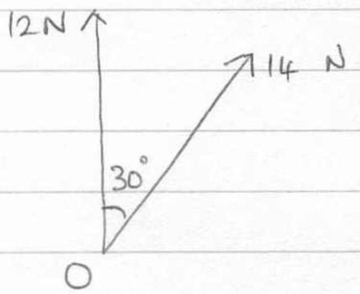
$\therefore t = 10$ seconds

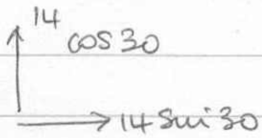
$\therefore s = \frac{1}{2}(14) \times 10$

$\therefore s = 70$ m.

2.

(i)





$R^2 = 12^2 + 14^2 - 2 \times 12 \times 14 \cos 150$

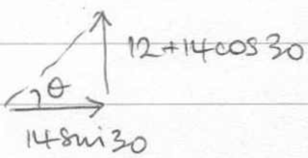
or

$R^2 = (12 + 14\cos 30)^2 + (14\sin 30)^2$

$\therefore R^2 = 630.98\ldots$

$R = 25.1$ N (3sf)

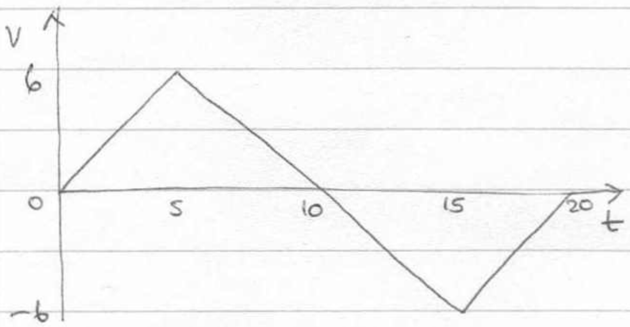
(ii)



$\tan\theta = \frac{(12 + 14\cos 30)}{14\sin 30}$ $\therefore \theta = 73.8\ldots^\circ$

Bearing $= 90 - \theta = 016^\circ$ (3sf) $[16.18\ldots]$

3.



(i) initial acceleration

$v = u + at$

$6 = 0 + 5a$

$\therefore a = \frac{6}{5} = 1.2\ m/s^2$

$\therefore a = 1.2\ m/s^2$

(ii) distance run is the area under the graph

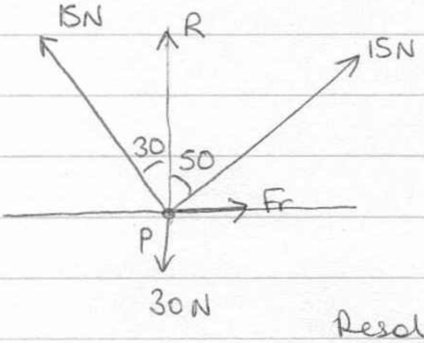
$s = \frac{1}{2} \times (10 \times 6) + \frac{1}{2} \times (10 \times 6) = 60$ metres.

(iii) When $t = 17$ seconds $v = u + at \Rightarrow v = -6 + 1.2 \times 2 = -3.6\ m/s$

(since the graph is symmetric a same as (i) or, $a = \frac{6}{5} = 1.2$

4.

(i)



Limiting Equilibrium. $F_r = \mu R$

Resolving vertically

$R + 15\cos 50 + 15\cos 30 = 30$

$\therefore R = 7.3678\ldots$

$\therefore R = 7.37$ N (3SF)

Resolving horizontally

$15\sin 30 = Fr + 15\sin 50$

$Fr = 15\sin 30 - 15\sin 50$

$\therefore Fr = -3.990\ldots$

$\therefore$ frictional force is 3.99 N (3SF) in direction $\leftarrow$

(ii) Coefficient of friction $\mu = \dfrac{Fr}{R} = \dfrac{3.99\ldots}{7.36\ldots} = 0.5416\ldots$

$\therefore \mu = 0.542$

5. before $u = 5 \rightarrow$ $\leftarrow u = -3$

A $m = 2400$ B $m = 3600$

using conservation of momentum

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

after

(i) $\overrightarrow{v}$ $\overrightarrow{v}$

$\therefore 2400(5) + 3600(-3) = 6000\,v$

$\therefore v = 0.2$ m/s

So wagon B changes direction

(ii) If after A $\leftarrow v_1$ B $\rightarrow v_2$ equal speeds

(a) $\therefore (2400)(5) + (3600)(-3) = 2400(-v) + 3600(v)$

$1200\,v = 1200$

$\therefore v = 1$ m/s

(b) change of momentum of A $= mv - mu$

$= 2400(1 - -5) = 14400$ Ns.

6. $x = 0.01t^4 - 0.16t^3 + 0.72t^2$ for $0 \le t \le 7$

(i) $v = \dfrac{dx}{dt} = 0.04t^3 - 0.48t^2 + 1.44t$

when $t = 2$, $v = 0.32 - 1.92 + 2.88 = 1.28$ m/s

(ii) $a = \frac{dv}{dt} = 0.12t^2 - 0.96t + 1.44$

When the acceleration is zero $0.12t^2 - 0.96t + 1.44 = 0$

$\therefore t^2 - 8t + 12 = 0$

(iii) minimum value of v is when acceleration ie $\frac{dv}{dt} = 0$

$\therefore (t-6)(t-2) = 0$

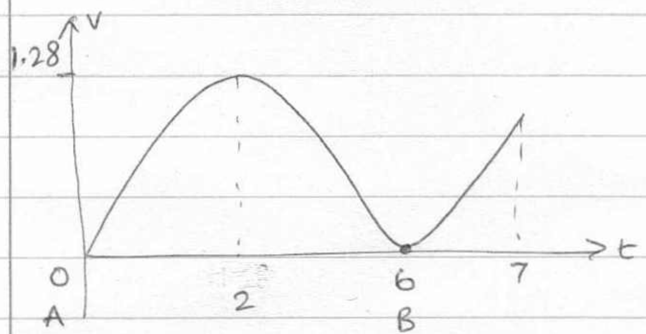
$\therefore t = 2$ or $t = 6$ seconds.

so if $t=2$ $v = 0.04 \times 2^3 - 0.48 \times 2^2 + 1.44 \times 2 = 1.28$ m/s

if $t=6$ $v = 0.04 \times 6^3 - 0.48 \times 6^2 + 1.44 \times 6 = 0$ m/s

minimum value of Velocity is 0 m/s.

(iv)



velocity is positive cubic

max $(2, 1.28)$

min $(6, 0)$

Comes to rest at B $(6, 0)$

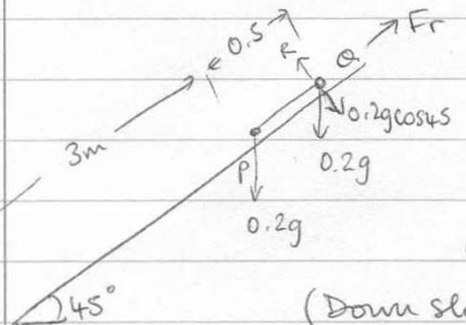
After B continues out from A.

(v) distance AB $x = 0.01 \times 6^4 - 0.16 \times 6^3 + 0.72 \times 6^2 = 4.32$

$\therefore$ AB is 4.32 metres.

7.

(i)



no friction at P. For Q, $\mu = 1$. $u = 0$.

using "F=ma" down the plane

$0.4g\sin 45 - Fr = 0.4a$

For particle Q

(Down slope) $0.2g\sin 45 + T - Fr = 0.2a$

(perp to slope) $R = 0.2g\cos 45$

Limiting friction $F = \mu R$ $F_r = 1 \times 0.2g\cos 45 = 1.3859\ldots$

$\therefore$ Frictional force $= 1.386$ N (4sf)

(ii) $\therefore 0.4g\sin 45 - Fr = 0.4a$ So using $Fr = 1.3859\ldots$

$\therefore 0.4a = 1.3859\ldots$ $\therefore a = 3.46$ m/s^2 (3sf)

The tension in the string, for P: down the slope using "F=ma"

$0.2g\sin 45 - T = 0.2a$ since $a = 3.46\ldots$

$\therefore T = 0.693$ N. (3sf)

(iii) when Q reaches 3m from the foot (ie where P was originally) it has moved 0.5 metres down the slope

$u = 0$ $\quad v^2 = u^2 + 2as$

$a = 3.465..$ $\quad v^2 = 0 + 2 \times 3.46\ldots \times 0.5$

$s = 0.5$ $\quad \therefore v = 1.861$ m/s

(iv) Now Q is detached from the string need times for P and Q at bottom of the slope - now moving with acceleration due to gravity (no longer $a = 3.46\ldots$)

For P: "F=ma" $0.2g\sin 45 = 0.2a$

$\therefore a = 6.93$ m/s^2

$u = 1.861$ (as above)

$a = 6.9296$ $\quad s = ut + \frac{1}{2}at^2$ $\quad v = u + at$

$s = 2.5$ $\quad 2 = 1.861t + \frac{1}{2}(6.9296)t^2$ $\quad v^2 = u^2 + 2as$

$\therefore v^2 = 1.861^2 + 2 \times 6.9296 \times 2.5$

$v = u + at \Rightarrow 6.173 = 1.861 + 6.929t$ $\quad \therefore v = 6.173\ldots$

$\therefore t = 0.62237\ldots$

$t = 0.622$ seconds

for Q: $0.2g\sin 45 - Fr = 0.2a$ and $Fr = 0.2g\cos 45$

$\therefore 0.2g\sin 45 - 0.2g\cos 45 = 0.2a$

$\therefore a = 0$ so Q moves at constant speed.

$\therefore s = ut$

$\therefore t = \frac{3}{1.861} = 1.612$ seconds

$\therefore$ difference in times for P and Q to reach foot of slope

$= 1.612 - 0.622$

$= 0.99$ seconds.