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| Candidate surname | Other names |
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| | |

**Pearson Edexcel International Advanced Level**

Centre Number | Candidate Number

Sample Assessment Materials for first teaching September 2018

(Time: 1 hour 30 minutes) | Paper Reference **WME02/01**

# Mathematics

## International Advanced Subsidiary/Advanced Level Mechanics M2

**You must have:**
Mathematical Formulae and Statistical Tables, calculator

Total Marks

**Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.**

## Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Inexact answers should be given to three significant figures unless otherwise stated.

## Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. The total mark for this paper is 75.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*

## Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

*Turn over*

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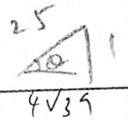
1. A car of mass 900 kg is travelling up a straight road inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{1}{25}$. The car is travelling at a constant speed of 14 m s$^{-1}$ and the resistance to motion from non-gravitational forces has a constant magnitude of 800 N. The car takes 10 seconds to travel from $A$ to $B$, where $A$ and $B$ are two points on the road.

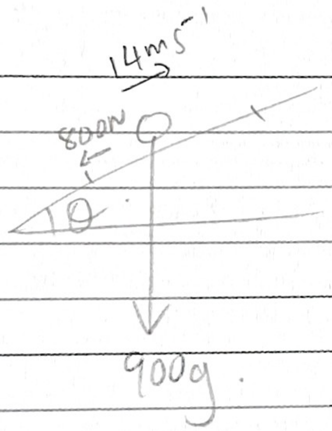
(a) Find the work done by the engine of the car as the car travels from $A$ to $B$.
**(4)**

When the car is at $B$ and travelling at a speed of 14 m s$^{-1}$ the rate of working of the engine of the car is suddenly increased to $P$ kW, resulting in an initial acceleration of the car of 0.7 m s$^{-2}$. The resistance to motion from non-gravitational forces still has a constant magnitude of 800 N.

(b) Find the value of $P$.
**(4)**




(1)




$\sin\theta = \frac{1}{25}$

$\cos\theta = \frac{4\sqrt{39}}{25}$

$\tan\theta = \frac{1}{4\sqrt{39}}$.

$D \times V =$ Power.

(✓) $D - \frac{900g}{25} - 800 = 0$

$D = 1152.8\text{N}$

$\therefore$ Power $= 1152.8 \times 14$

$= 16139.2\text{W}$.

Power $= \frac{wd}{t}$

$\therefore wd = \boxed{\text{Power} \times t}$

$16139.2 \times 10 = 161392\text{J}$.

$\simeq 161\text{ kJ}$



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Question 1 continued

(b) $D - 800 - \frac{900g}{25} = 900 \times 0.7$

$D = 1782.8\text{ N}$

$P = D \times V$

$= 1782.8 \times 14$

$= 24959.2\text{ W}$

$\simeq 25\text{ kW}$

$\therefore P = 25$

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2. A particle $P$ of mass 0.7 kg is moving in a straight line on a smooth horizontal surface. The particle $P$ collides with a particle $Q$ of mass 1.2 kg which is at rest on the surface. Immediately before the collision the speed of $P$ is $6\,\text{m}\,\text{s}^{-1}$. Immediately after the collision both particles are moving in the same direction. The coefficient of restitution between the particles is $e$.

(a) Show that $e < \frac{7}{12}$ **(7)**

Given that $e = \frac{1}{4}$

(b) find the magnitude of the impulse exerted on $Q$ in the collision. **(3)**

(2)

P: 0.7kg, $\rightarrow$ 6ms$^{-1}$, $\rightarrow V_1$

Q: 1.2kg, 0, $\rightarrow V_2$

$\frac{V_2 - V_1}{6} = e$

$V_2 - V_1 = 6e$

$V_2 = 6e + V_1$

$0.7(6) = 0.7(V_1) + 1.2(V_2)$

$4.2 = 0.7V_1 + 1.2V_2$

$4.2 = 0.7V_1 + 1.2(6e + V_1)$

$4.2 = 0.7V_1 + 1.2V_1 + 7.2e$

$1.9V_1 = 4.2 - 7.2e$

$V_1 = \frac{4.2 - 7.2e}{1.9}$

$V_2 = 6e + \frac{4.2 - 7.2e}{1.9}$

$\frac{4.2e + 4.2}{1.9} = V_2$

$V_1 > 0$

$\downarrow$

~~$4.2e + 4.2 > 0$~~

$\frac{4.2 - 7.2e}{1.9} > 0$

$4.2 > 7.2e$

$\frac{7}{12} > e$



P 4 6 9 6 0 R A 0 6 2 8

Question 2 continued

$e < \frac{7}{12}$ as required

(b) $V_1 = \frac{4.2 - 7.2(0.25)}{1.9}$

$V_1 = \frac{24}{19}$

$0.7\left(-\frac{24}{19} + 6\right)$

$I = \frac{63}{19}$ NS

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3. At time $t$ seconds ($t \geqslant 0$) a particle $P$ has velocity $\mathbf{v}$ m s$^{-1}$, where

$$\mathbf{v} = (6t^2 + 6t)\mathbf{i} + (3t^2 + 24)\mathbf{j}$$

When $t = 0$ the particle $P$ is at the origin $O$. At time $T$ seconds, $P$ is at the point $A$ and $\mathbf{v} = \lambda(\mathbf{i} + \mathbf{j})$, where $\lambda$ is a constant.

Find

(a) the value of $T$, (3)

(b) the acceleration of $P$ as it passes through the point $A$, (3)

(c) the distance $OA$. (5)

$v = (6t^2+6t)i + (3t^2+24)j.$

$6t^2+6t = \lambda.$

$3t^2+24 = \lambda.$

$6t^2+6t = 3t^2+24.$

$3t^2+6t-24=0.$

$\dfrac{-6 \pm \sqrt{6^2-4(3)(-24)}}{2\times 3}$

$t=-4$ or $t=2.$

4

N/A $\boxed{T=2}$

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Question 3 continued

(b) $\frac{dv}{dt} = (12t+6)i + (6t+0)j.$

when $t=2$.

$(12(2)+6)i + (6(2))j.$

$\Rightarrow 30i + 12j.$

(c) $\int v \, dt.$

$= \left[\frac{6t^3}{3} + \frac{6t^2}{2}\right]i + \left[t^3+24t\right]j.$

$(2t^3+3t^2)i + (t^3+24t)j. + C$

when $t=0$ $s=0$ $\therefore C=0$.

$\therefore s = (2t^3+3t^2)i + (t^3+24t)j.$

$\left[(2t^3+3t^2)i + (t^3+24t)j\right]_0^2$

$28i + 56j - 0.$

disp $= 28i + 56j.$

$\sqrt{(28)^2+(56)^2} = 28\sqrt{5}$ m.

$\underline{62.6}$m. (3sf)

Q3

(Total 11 marks)

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4.

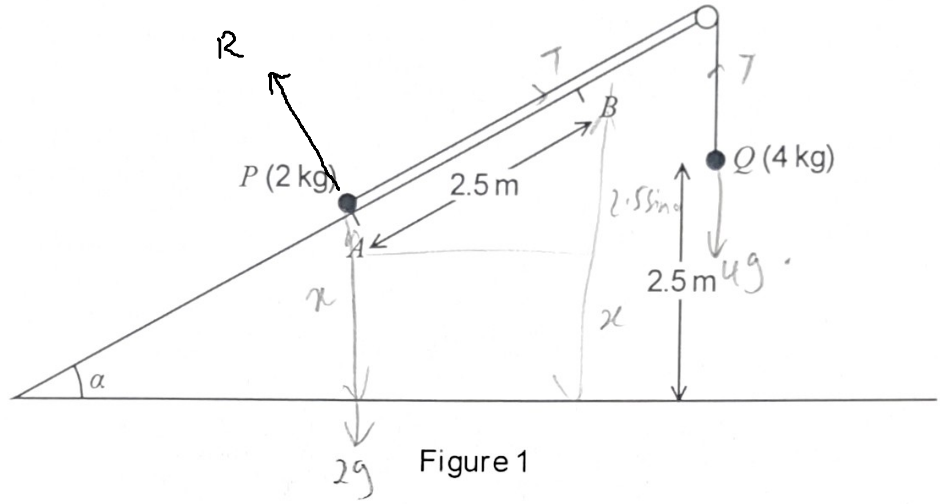


Figure 1

Two particles $P$ and $Q$, of mass 2 kg and 4 kg respectively, are connected by a light inextensible string. Initially $P$ is held at rest at the point $A$ on a rough fixed plane inclined at $\alpha$ to the horizontal ground, where $\sin\alpha = \frac{3}{5}$. The string passes over a small smooth pulley fixed at the top of the plane. The particle $Q$ hangs freely below the pulley and 2.5 m above the ground, as shown in Figure 1. The part of the string from $P$ to the pulley lies along a line of greatest slope of the plane. The system is released from rest with the string taut. At the instant when $Q$ hits the ground, $P$ is at the point $B$ on the plane. The coefficient of friction between $P$ and the plane is $\frac{1}{4}$.

(a) Find the work done against friction as $P$ moves from $A$ to $B$.

(4)

(b) Find the total potential energy lost by the system as $P$ moves from $A$ to $B$.

(3)

(c) Find, using the work-energy principle, the speed of $P$ as it passes through $B$.

(4)

a) Loss in PE − gain in KE = wd

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

$R = 2g\cos\alpha$

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

$R = 2g \times \frac{4}{5} = \frac{8g}{5}$

$\mu = \frac{1}{4}$.

$F = \frac{8g}{5} \times \frac{1}{4} = \frac{2g}{5}$ → Friction

$wd = \frac{2}{5}g \times 2.5 = 9.8\,J$

$(gJ)$



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Question 4 continued

For P.

(b) PE at A.

$2gx$

PE at B:

$2g \times (x + 2.5 \sin d)$

$2g \times (x + 1.5)$

$\therefore$ Change in PE:

$\cancel{2gx} + 3g - \cancel{2gx}$

$= 3g$

For Q

At top

$4g \times 2.5 \quad = 10g.$

at bottom

$= 0.$

$\therefore$ change $= 10g$

$\therefore 3g - 10g = -7g$

$\therefore$ PE lost $= 7g.$

(c) Speed of both particles at B i.e after 2.5m?

Loss in gpe - gain in KE = wd.

$7g - \frac{1}{2} \times (4+2) \times v^2 = g.$

$6g = 3 \times v^2$

$v^2 = 19.6$

$v = \frac{7\sqrt{10}}{5} ms^{-1}$

$= 4.43 ms^{-1}$



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5.

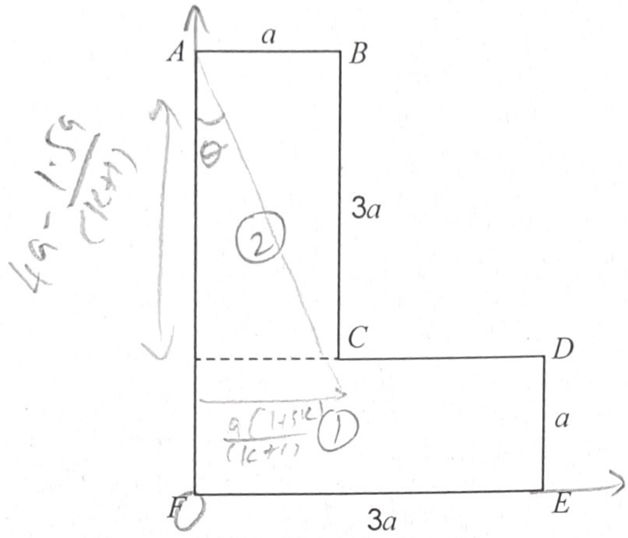


Figure 2

The uniform lamina $ABCDEF$, shown in Figure 2, consists of two identical rectangles with sides of length $a$ and $3a$. The mass of the lamina is $M$. A particle of mass $kM$ is attached to the lamina at $E$. The lamina, with the attached particle, is freely suspended from $A$ and hangs in equilibrium with $AF$ at an angle $\theta$ to the downward vertical.

Given that $\tan\theta = \frac{4}{7}$, find the value of $k$.

(10)

5) 1.

Area

$3a^2$

COM

$\begin{pmatrix} 1.5a \\ 0.5a \end{pmatrix}$

2.

Area $= 3a^2$

COM

$\begin{pmatrix} 0.5a \\ 2.5a \end{pmatrix}$

$3a^2\begin{pmatrix} 1.5a \\ 0.5a \end{pmatrix} + 3a^2\begin{pmatrix} 0.5a \\ 2.5a \end{pmatrix}$

$= 6a^2\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix}$.

$\begin{pmatrix} 4.5a + 1.5a \\ 1.5a + 7.5a \end{pmatrix} = 6\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix}$

$\begin{pmatrix} 6a \\ 9a \end{pmatrix} = 6\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix}$

$\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix} = \begin{pmatrix} a \\ 1.5a \end{pmatrix}$



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Question 5 continued

$M\begin{pmatrix} a \\ 1.5a \end{pmatrix} + kM\begin{pmatrix} 3a \\ 0 \end{pmatrix} =$

$M(k+1)\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix}$

$\begin{pmatrix} a+3ka \\ 1.5a \end{pmatrix} = (k+1)\begin{pmatrix} \bar{x} \\ \bar{y} \end{pmatrix}$

$\bar{x} = \dfrac{a(1+3k)}{(k+1)}$

$\bar{y} = \dfrac{1.5a}{(k+1)}$

$\tan\theta = \dfrac{4}{7}$

$\dfrac{\bar{x}}{4a-\bar{y}} = \dfrac{4}{7}$

$4a - \bar{y} = \left[\dfrac{4(k+1)-1.5}{k+1}\right]a$

$= \dfrac{4k+4-1.5}{k+1}a$

$= \dfrac{a\cdot(4k+2.5)}{k+1}$

$\dfrac{a(1+3k)}{(k+1)} \div \dfrac{a(4k+2.5)}{(k+1)} = \dfrac{4}{7}$

$\dfrac{\cancel{a}(1+3k)}{\cancel{(k+1)}} \times \dfrac{\cancel{(k+1)}}{\cancel{a}(4k+2.5)} = \dfrac{4}{7}$

$\dfrac{1+3k}{4k+2.5} = \dfrac{4}{7}$

$7+21k = 16k+10$

$5k = 3$

$k = \dfrac{3}{5}$



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6.

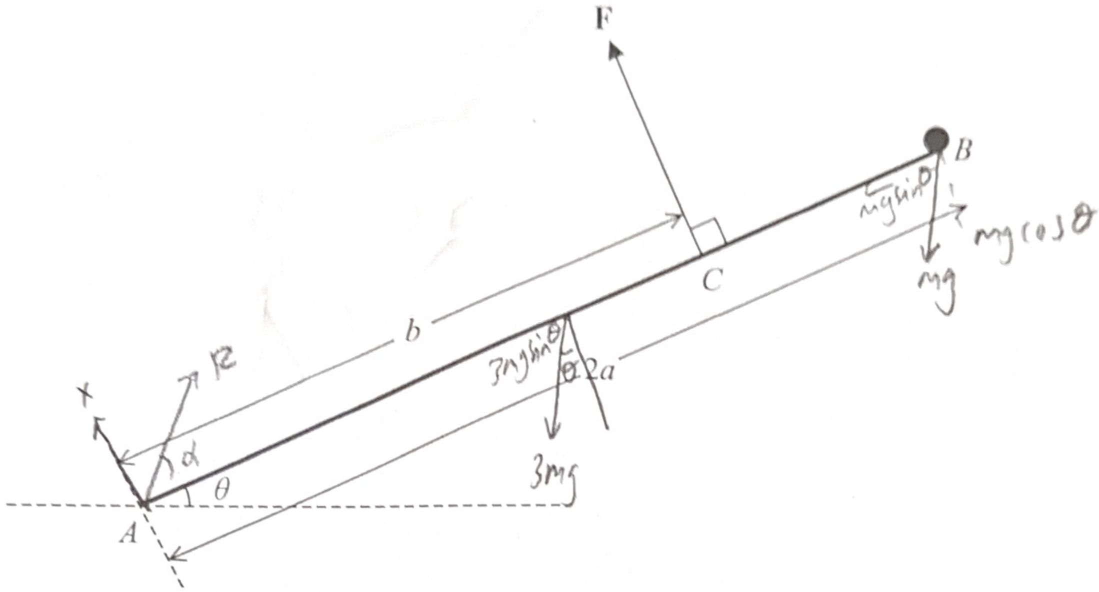


**Figure 3**

A uniform rod $AB$, of mass $3m$ and length $2a$, is freely hinged at $A$ to a fixed point on horizontal ground. A particle of mass $m$ is attached to the rod at the end $B$. The system is held in equilibrium by a force **F** acting at the point $C$, where $AC = b$. The rod makes an acute angle $\theta$ with the ground, as shown in Figure 3. The line of action of **F** is perpendicular to the rod and in the same vertical plane as the rod.

(a) Show that the magnitude of **F** is $\frac{5mga}{b}\cos\theta$ **(4)**

The force exerted on the rod by the hinge at $A$ is **R**, which acts upwards at an angle $\phi$ above the horizontal, where $\phi > \theta$.

(b) Find

(i) the component of **R** parallel to the rod, in terms of $m$, $g$ and $\theta$,

(ii) the component of **R** perpendicular to the rod, in terms of $a$, $b$, $m$, $g$ and $\theta$. **(5)**

(c) Hence, or otherwise, find the range of possible values of $b$, giving your answer in terms of $a$. **(2)**

(a) M(A).

$(a \times 3mg\cos\theta) + 2a(mg\cos\theta) = F \times b$

$3amg\cos\theta + 2amg\cos\theta$

$= 5amg\cos\theta.$

$Fb = 5amg\cos\theta$

$F = \frac{5amg\cos\theta}{b}$

as req.

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Question 6 continued

bi) $R(\rightarrow)$.

$= Y - 3mg\sin\theta - mg\sin\theta = 0$

$Y = 4mg\sin\theta$

ii) $R(\uparrow)$

upward - downward $= 0$

$X + F - 3mg\cos\theta - mg\cos\theta = 0$

$X = -F + 4mg\cos\theta$

$X = -\frac{5mga}{b}\cos\theta + 4mg\cos\theta$

$X = \frac{mg\cos\theta(4b-5a)}{b}$

$\frac{4b-5a}{5} > 0$

$4b > 5a$

$b > 5/4\, a$

$\therefore \frac{5a}{4} < b \leq 2a$

(c) $\phi > \theta$

$\phi - \theta > 0$. $\therefore \tan(\phi - \theta) > 0$

$\frac{X}{Y} > 0$

$$\frac{\frac{mg\cos\theta(4b-5a)}{b}}{\frac{5mga\cdot\cos\theta}{b}}$$

Q6

(Total 11 marks)



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7.

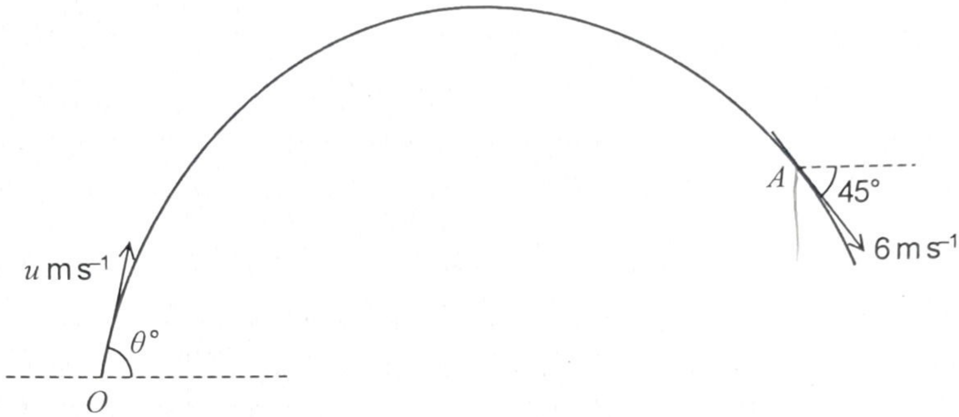


Figure 4

At time $t$ = 0, a particle $P$ of mass 0.7 kg is projected with speed $u$ m s$^{-1}$ from a fixed point $O$ at an angle $\theta°$ to the horizontal. The particle moves freely under gravity. At time $t$ = 2 seconds, $P$ passes through the point $A$ with speed 6 m s$^{-1}$ and is moving downwards at 45° to the horizontal, as shown in Figure 4.

Find

(a) the value of $\theta$, **(6)**

(b) the kinetic energy of $P$ as it reaches the highest point of its path. **(3)**

For an interval of $T$ seconds, the speed, $v$ m s$^{-1}$, of $P$ is such that $v \leqslant 6$

(c) Find the value of $T$. **(5)**

(a) $u\cos\theta = 6\cos 45$

$u\cos\theta = 3\sqrt{2}$ -- (1)

S

$u = u\sin\theta$

$v = -6\cos 45$.

$a = -9.8$

$t = 2$

$\frac{-6\cos 45 - u\sin\theta}{2} = -9.8$

$19.6 = 6\cos 45 + u\sin\theta$.

$u\sin\theta = \frac{98 - 15\sqrt{2}}{5}$ -- (2)

$\frac{u\sin\theta}{u\cos\theta} = \tan\theta$

$\frac{98 - 15\sqrt{2}}{5 \times 3\sqrt{2}} = \tan\theta$

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Question 7 continued

$\tan\theta = \frac{-15+49\sqrt{2}}{15}$

$\theta = 74.6^\circ$

(b) KE is scalar

$\therefore \frac{1}{2} \times 0.7 \times v^2$

$v\cos\theta \rightarrow$ Horizontal component

and $u_{vertical} = 0$.

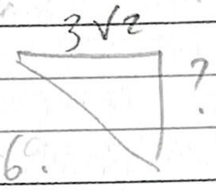
from eqn (1)

$u\cos\theta = 3\sqrt{2}$.

$\therefore \frac{1}{2} \times 0.7 \times (3\sqrt{2})^2$

$= 6.3\text{J}$

(c)




$\sqrt{6^2 - (3\sqrt{2})^2}$

$= 3\sqrt{2} \rightarrow$ vertical component

$s$

$u = 3\sqrt{2}$

$v = -3\sqrt{2}$

$a = -9.8$

$t = ?$

$v = u + at$

$-3\sqrt{2} = 3\sqrt{2} - gt$

$t = 0.8658$

$\simeq 0.87$