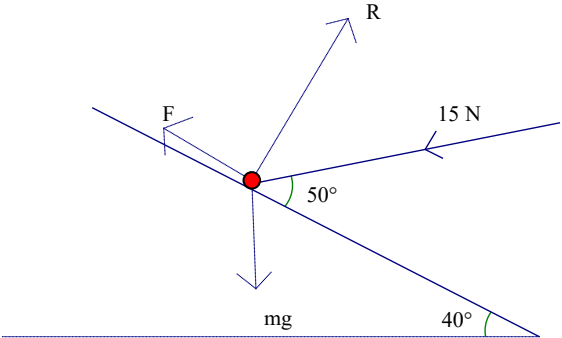


**A level Mathematics Practice Paper – Dynamics of a particle – Mark scheme**

| Question    | Scheme                                                                                                            | Marks                         |
|-------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------|
| <b>1(a)</b> | $R = mg \cos 40$                                                                                                  | B1                            |
|             | Use of $F = \mu R$                                                                                                | B1                            |
|             | $mg \sin 40 - F = \pm ma$                                                                                         | M1A1                          |
|             | $acc = 2.55 \text{ (m s}^{-2}\text{) or } 2.5 \text{ (m s}^{-2}\text{)}$                                          | A1                            |
|             |                                                                                                                   | <b>(5)</b>                    |
| <b>1(b)</b> | $v^2 = u^2 + 2as = 2 \times a \times 3$ Speed at B is 3.9 (m s <sup>-1</sup> ) or 3.91(m s <sup>-1</sup> )        | M1A1                          |
|             |                                                                                                                   | <b>(2)</b>                    |
|             |                                                                                                                   | <b>(7 marks)</b>              |
| <b>2</b>    | $12.6^2 = 2a.50 \quad (\Rightarrow a = 1.5876)$<br>$800g \sin 15 - F = 800a$<br>$R = 800g \cos 15$<br>$F = \mu R$ | M1 A1<br>M1 A1<br>M1 A1<br>B1 |
|             | $800g \sin 15 - \mu 800g \cos 15 = 800 \times 1.5876$<br>$\mu = 0.1, 0.10, 0.100$                                 | M1<br>A1                      |
|             |                                                                                                                   | <b>(9 marks)</b>              |
| <b>3(a)</b> | speed = $\sqrt{2^2 + (-5)^2}$                                                                                     | M1                            |
|             | $= \sqrt{29} = 5.4$ or better                                                                                     | A1                            |
|             |                                                                                                                   | <b>(2)</b>                    |
| <b>3(b)</b> | $((7i + 10j) - (2i - 5j))/5$                                                                                      | M1 A1                         |
|             | $= (5i + 15j)/5 = i + 3j$                                                                                         | A1                            |
|             | $F = ma = 2(i + 3j) = 2i + 6j$                                                                                    | DM1 A1ft                      |
|             |                                                                                                                   | <b>(5)</b>                    |
| <b>3(c)</b> | $v = u + at = (2i - 5j) + (i + 3j)t$                                                                              | M1                            |
|             | $(-5 + 3t)j$                                                                                                      | A1                            |
|             | Parallel to i $\Rightarrow -5 + 3t = 0$                                                                           | M1                            |
|             | $t = 5/3$                                                                                                         | A1                            |
|             |                                                                                                                   | <b>(4)</b>                    |
|             |                                                                                                                   | <b>(11 marks)</b>             |

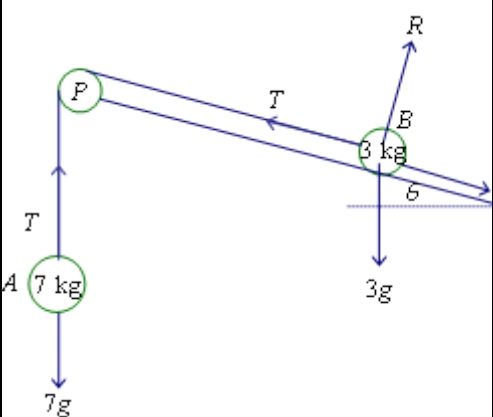
**A level Mathematics Practice Paper – Dynamics of a particle – Mark scheme**

| Question    | Scheme                                                                                  | Marks             |
|-------------|-----------------------------------------------------------------------------------------|-------------------|
| <b>4(a)</b> | Use of $v^2 = u^2 + 2as$                                                                | M1                |
|             | $14^2 = 20^2 - 2a \times 100$                                                           | A1                |
|             | Deceleration is $1.02(\text{m s}^{-2})$                                                 | A1                |
|             |                                                                                         | <b>(3)</b>        |
| <b>4(b)</b> | Horizontal forces on the car: $\pm T \cos \theta - 300 = 750 \times -1.02 = -765$       | M1A2 f.t.         |
|             | $T = -1550/3$                                                                           |                   |
|             | The force in the tow-bar is $1550/3$ , $520 \text{ (N)}$ or better (allow $-ve$ answer) | A1                |
|             |                                                                                         | <b>(4)</b>        |
| <b>4(c)</b> | Horizontal forces on the truck: $\pm T \cos \theta - 500 - R = 1750 \times -1.02$       | M1A2 f.t.         |
|             | Braking force $R = 1750 \text{ (N)}$                                                    | A1                |
|             |                                                                                         | <b>(4)</b>        |
|             |                                                                                         | <b>(11 marks)</b> |
| <b>5(a)</b> |       |                   |
|             | Perpendicular to the slope: $R = 2.7g \cos 40 + 15 \cos 40$                             | M1A2              |
|             | $= 31.8 \text{ (N)}$ or $32 \text{ (N)}$                                                | A1                |
|             |                                                                                         | <b>(4)</b>        |
| <b>5(b)</b> | Parallel to the slope: $F = 2.7g \sin 40 - 15 \cos 50 \quad (F = 7.366..)$              | M1A2              |
|             | Use of $F = \mu R$                                                                      | M1                |
|             | $\mu = \frac{2.7g \sin 40 - 15 \cos 50}{R} = 0.23 \text{ or } 0.232$                    | A1                |
|             |                                                                                         | <b>(5)</b>        |
| <b>5(c)</b> | Component of wt parallel to slope $= 2.7g \sin 40^\circ (=17.0)$                        | B1                |
|             | $F_{\max} = 0.232 \times 2.7 \times g \times \cos 40^\circ = 4.7... \text{ (N)}$        | M1A1              |
|             | $17.0 > 4.7$ so the particle moves                                                      | A1                |
|             |                                                                                         | <b>(4)</b>        |
|             |                                                                                         | <b>(13 marks)</b> |

**A level Mathematics Practice Paper – Dynamics of a particle – Mark scheme**

| Question    | Scheme                                                                                                                                                    | Marks                                |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| <b>6(a)</b> | Inextensible string                                                                                                                                       | B1                                   |
|             |                                                                                                                                                           | <b>(1)</b>                           |
| <b>6(b)</b> | $4mg - T = 4ma$<br>$T - 2mg \sin \alpha - F = 2ma$                                                                                                        | M1A1<br>M1A1                         |
|             |                                                                                                                                                           | <b>(4)</b>                           |
| <b>6(c)</b> | $F = 0.25R$<br>$R = 2mg \cos \alpha$<br>$\cos \alpha = 0.8$ or $\sin \alpha = 0.6$<br>Eliminating $R$ , $F$ and $T$<br>$a = 0.4g = 3.92$                  | B1<br>B1<br>B1<br>M1<br>A1           |
|             |                                                                                                                                                           | <b>(5)</b>                           |
| <b>6(d)</b> | $v^2 = 2 \times 0.4gh$<br>$-2mg \sin \alpha - F = 2ma'$<br>$a' = -0.8g$<br>$0^2 = 0.8gh - 2 \times 0.8g \times s$<br>$s = 0.5h$<br>$XY = 0.5h + h = 1.5h$ | M1<br>M1<br>A1<br><br>M1<br>A1<br>A1 |
|             |                                                                                                                                                           | <b>(6)</b>                           |
|             |                                                                                                                                                           | <b>(16 marks)</b>                    |

**A level Mathematics Practice Paper – Dynamics of a particle – Mark scheme**

| Question | Scheme                                                                                                      | Marks             |
|----------|-------------------------------------------------------------------------------------------------------------|-------------------|
| 7(a)     |                            |                   |
|          | $\tan \theta = \frac{5}{12}$                                                                                |                   |
|          | $\sin \theta = \frac{5}{13}$                                                                                |                   |
|          | $\cos \theta = \frac{12}{13}$                                                                               |                   |
|          | For A: $7g - T = 7a$                                                                                        | M1 A1             |
|          | For B: parallel to plane $T - 3g \sin \theta = 3a$                                                          | M1 A1             |
|          | perpendicular to plane $R = 3g \cos \theta$                                                                 | M1 A1             |
|          | $F = \mu R = 3g \cos \theta = 2g \cos \theta$                                                               | M1                |
|          | Eliminating $T$ , $7g - 3g \sin \theta = 10a$                                                               | DM1               |
|          | Equation in $g$ and $a$ : $7g - 2g \times \frac{12}{13} - 3g \frac{5}{13} = 7g - \frac{39}{13}g = 4g = 10a$ | DM1               |
|          | $a = \frac{2g}{5}$ oe or 3.9 or 3.92                                                                        | A1                |
|          |                                                                                                             |                   |
|          |                                                                                                             | <b>(10)</b>       |
| 7(b)     | After 1 m,                                                                                                  |                   |
|          | $v^2 = u^2 + 2as$ , $v^2 = 0 + 2 \times \frac{2g}{5} \times 1$                                              | M1                |
|          | $v = 2.8$                                                                                                   | A1                |
|          |                                                                                                             | <b>(2)</b>        |
| 7(c)     | $-(F + 3g \sin \theta) = 3a$                                                                                | M1                |
|          | $\frac{2}{3} \times 3g \times \frac{12}{13} + 3g \times \frac{5}{13} = 3g = -3a$ , $\hat{a} = -g\hat{i}$    | A1                |
|          | $v = u + at$ , $0 = 2.8 - 9.8t$ ,                                                                           | DM1               |
|          | $t = \frac{2}{9.8}$ oe, 0.29. 0.286                                                                         | A1                |
|          |                                                                                                             | <b>(4)</b>        |
|          |                                                                                                             | <b>(16 marks)</b> |

**A level Mathematics Practice Paper – Dynamics of a particle – Mark scheme**

| Question | Scheme                                                                                                                                                                                            | Marks                                       |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| 8(a)     | For $A$ : $T - F = 2ma$<br>For $B$ : $mg - T = ma$                                                                                                                                                | M1 A1<br><br>M1 A1                          |
|          |                                                                                                                                                                                                   | <b>(4)</b>                                  |
| 8(b)     | $R = 2mg$<br>$mg(1 - 2\mu) = 3ma$<br>$\frac{g}{3}(1 - 2\mu) = a$                                                                                                                                  | B1<br>M1<br><br>A1                          |
|          |                                                                                                                                                                                                   | <b>(3)</b>                                  |
| 8(c)     | $v^2 = \frac{2gh}{3}(1 - 2\mu)$<br>$v = \sqrt{\frac{2gh}{3}(1 - 2\mu)}$                                                                                                                           | M1<br><br>A1                                |
|          |                                                                                                                                                                                                   | <b>(2)</b>                                  |
| 8(d)     | $-\mu R = 2ma'$<br>$0^2 = \text{their } u^2 - 2a's$<br>$0 = \frac{2gh}{3}(1 - \frac{2}{3}) - 2(\frac{1}{3}g)s$ (or $s = (d - h)$ )<br>$s = \frac{1}{3}h$<br>$d = \frac{1}{3}h + h = \frac{4}{3}h$ | M1<br><br>M1<br><br>A1 (A1)<br><br>A1<br>A1 |
|          |                                                                                                                                                                                                   | <b>(5)</b>                                  |
| 8(e)     | $A$ (or $B$ ) would not move; <b>OR</b> $A$ (or $B$ ) would remain in (limiting) equilibrium; <b>OR</b> the system would remain in (limiting) equilibrium                                         | B1                                          |
|          |                                                                                                                                                                                                   | <b>(1)</b>                                  |
|          |                                                                                                                                                                                                   | <b>(15 marks)</b>                           |

**A level Mathematics Practice Paper – Dynamics of a particle – Mark scheme**

| Question | Scheme                                                                                                                                                                                             | Marks                                               |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| 9(a)     | $F = \frac{1}{5}R$<br>$R = 1.5g$<br>$T - F = 1.5a$<br>$3g - T = 3a$<br>$T = 1.2g$ or 11.8 N or 12 N                                                                                                | M1<br>B1<br><br>M1 A1<br>M1 A1<br><br><b>DM1</b> A1 |
|          |                                                                                                                                                                                                    | <b>(8)</b>                                          |
| 9(b)     | $R = \sqrt{T^2 + T^2}$ or $2T \cos 45^\circ$ or $\frac{T}{\cos 45^\circ}$<br>$= 16.6 \text{ (N)}$ or $17 \text{ (N)}$ or $\frac{6g\sqrt{2}}{5}$<br>Direction is $45^\circ$ below the horizontal oe | M1 A1<br><br>A1<br><br>B1                           |
|          |                                                                                                                                                                                                    | <b>(4)</b>                                          |
|          |                                                                                                                                                                                                    | <b>(12 marks)</b>                                   |

**A level Mathematics Practice Paper – Dynamics of a particle – Mark scheme**

|   | Source paper | Question number | New spec references | Question description                                               | New AOs                              |
|---|--------------|-----------------|---------------------|--------------------------------------------------------------------|--------------------------------------|
| 1 | M1 2014      | 2               |                     | Dynamics of a particle moving in a straight line or plane          | 1.1b, 3.1b, 3.4                      |
| 2 | M1 Jan 2013  | 4               |                     | Dynamics of a particle moving in a straight line or plane          | 1.1b, 1.2, 2.2a, 3.3, 3.4            |
| 3 | M1 Jan 2011  | 4               |                     | Vectors, Dynamics of a particle moving in a straight line or plane | 1.1b, 2.2a, 3.1a, 3.1b               |
| 4 | M1 2013R     | 7               |                     | Dynamics of a particle moving in a straight line or plane          | 1.1b, 2.2a, 3.1b, 3.3, 3.4           |
| 5 | M1 2014R     | 7               |                     | Dynamics of a particle moving in a straight line or plane          | 1.1b, 2.1, 2.2a, 2.4, 3.1b           |
| 6 | M1 Jan 2013  | 7               |                     | Dynamics of a particle moving in a straight line or plane          | 1.1b, 1.2, 2.1, 2.2a, 2.4, 3.1b, 3.4 |
| 7 | M1 Jan 2011  | 7               |                     | Dynamics of a particle moving in a straight line or plane          | 1.1b, 1.2, 2.1, 2.2a, 3.1b, 3.4      |
| 8 | M1 2017      | 8               |                     | Dynamics of a particle moving in a straight line or plane          | 1.1b, 2.2a, 3.3, 3.4, 3.5a           |
| 9 | M1 2016      | 8               |                     | Dynamics of a particle moving in a straight line or plane          | 1.1b, 1.2, 2.1, 2.2a, 3.1b, 3.4      |