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| --- | --- | --- | --- | --- |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress descriptor |
| **1a** | Force descriptions in words × 3 (one mark each)  Force values ×3 (one mark each) | **B3**  **B3** | 2.5  1.1b | 3rd  Draw force diagrams. |
|  | **(6)** |  |  |
| **1b** | Limiting equilibrium means *F* = *μR* | **M1** | 3.1b | 7th  The concept of limiting equilibrium. |
| *P* = 0.3 × 9.8 × 5 | **M1** | 1.1b |
| *P* = 14.7 (N) accept awrt 15 (N) | **A1** | 1.1b |
|  | **(3)** |  |  |
| (9 marks) | | | | |
| Notes  **1b**  Allow if *g* explicitly evaluated. | | | | |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress descriptor |
| **2** | **F**1 + **F**2 + **F**3 or **F**3 = −(**F**1 + **F**2) | **M1** | 1.1a | 4th  Calculate resultant forces using vectors. |
|  | **M1** | 1.1b |
|  | **A1** | 1.1b |
| (3 marks) | | | | |
| Notes | | | | |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress descriptor |
| **3a** | B1 for each correct force with correct label | **B4** | 2.5 | 3rd  Draw force diagrams. |
|  | **(4)** |  |  |
| **3b** | Res(→) *F* = *P* cos 30 | **M1** | 3.1b | 5th  Calculate resultant forces in perpendicular directions. |
|  | **A1** | 1.1b |
| Res(↑) *R* = 5*g* − *P* sin 30 | **M1** | 3.1b |
|  | **A1** | 1.1b |
|  | **(4)** |  |  |
| **3c** | If *P* = 20,  Substitute into *R*  *R* = 39 N | **M1**  **A1** | 1.1b  1.1b | 7th  The concept of limiting equilibrium. |
| Substitute into F  *F* = or 17.320… (N) | **M1**  **A1** | 1.1b  1.1b |
| If limiting equilibrium, *μ*or 0.444…  So *μ* ⩾or *μ* ⩾ 0.44 | **M1**  **A1ft** | 3.1b  3.2a |
|  | **(6)** |  |  |
| (14 marks) | | | | |
| Notes  **3b**  Allow if *g* explicitly evaluated. | | | | |
| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress descriptor |
| **4a** | One correct force with correct label.  Two more correct forces with correct labels. | **B1**  **B1** | 2.5  2.5 | 3rd  Draw force diagrams. |
|  | **(2)** |  |  |
| **4b** | Resolve vertically. | **M1** | 1.1b | 5th  Calculate resultant forces in perpendicular directions. |
| Weight = 8*g* | **M1** | 1.1b |
| = 78.4 | **M1** | 1.1b |
| Vertical part of normal reaction is 2*R* cos 40 | **A1** | 1.1b |
| 2*R* cos 40 = 78.4 | **M1** | 1.1b |
| Solve for *R* | **M1** | 1.1b |
| *R* = 51.171… (N) accept awrt 51 | **A1** | 1.1b |
|  | **(7)** |  |  |
| (9 marks) | | | | |
| Notes | | | | |

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| Q | Scheme | Marks | AOs | Pearson Progression Step and Progress descriptor |
| **5a** | B1 for each correct force with correct label. | **B3** | 2.5 | 3rd  Draw force diagrams. |
|  | **(3)** |  |  |
| **5b** | Resolve horizontally/vertically or along/perp to plane. | **M1** | 1.1b | 7th  The concept of limiting equilibrium. |
| *R* = 3*g* cos *θ* | **A1** | 1.1b |
|  | **A1** | 1.1b |
| Limiting equilibrium means  *μR* = 3*μg*cos*θ* | **A1** | 1.1b |
| 3*μg*cos*θ =* 3*g*sin*θ* | **M1** | 1.1b |
| *μ =*tan*θ* | **A1** | 1.1b |
|  | **(6)** |  |  |
| **5c** | tan30 = 0.577… | **A1** | 3.1a | 7th  The concept of limiting equilibrium. |
| For limiting equilibrium, *μ* = 0.577… | **M1** | 3.1a |
| But *μ* = 0.3 so less friction. | **M1** | 3.1a |
| Hence the object slips. | **A1** | 3.2a |
|  | **(4)** |  |  |
| **5d** | No object would remain in equilibrium,  because normal reaction becomes zero. | **B1**  **A1** | 3.2a | 7th  The concept of limiting equilibrium. |
|  | **(2)** |  |  |
| (15 marks) | | | | |
| Notes  **5b**  Allow calculations with *g* explicitly evaluated. | | | | |