

Essential Knowledge Milestones	Teaching Points
<ul style="list-style-type: none"> <li>understand that a rough plane will have an associated frictional force, which opposes relative motion (i.e. the direction of the frictional force is always opposite to how the object is moving or 'wants' to move);</li> <li>understand that the 'roughness' of two surfaces is represented by a value called the coefficient of friction represented by <math>\mu</math>;</li> <li>know that <math>0 \leq \mu</math> but that there is no theoretical upper limit for <math>\mu</math> although for most surfaces it tends to be less than 1 and that a 'smooth' surface has a value of <math>\mu = 0</math>;</li> <li>be able to draw force diagrams involving rough surfaces which include the frictional force</li> <li>understand and be able to use the formula <math>F \leq \mu R</math>.</li> </ul>	<ul style="list-style-type: none"> <li>Start by asking students to rub their hands together vigorously. The warmth is caused by microscopic peaks and troughs on the surface of the skin interlocking. The rougher the surface, the 'sharper' these peaks and troughs. Explain to students that this principle applies even to the smoothest looking surfaces and the force which opposes motion is called the frictional force. The value which represents the roughness is called the coefficient of friction (<math>\mu</math>) and is zero for a smooth surface.</li> <li>If we consider a book on a rough horizontal table, it will be <i>harder</i> to move the book if:- we put a 'paperweight' on it (increasing the reaction force) or we put it on a rougher surface (increasing the value of <math>\mu</math>).</li> <li>Therefore the expression to model frictional forces uses these two factors (in direct proportion) and is given by <math>\mu R</math>. This is the maximum resistance any surface can provide before the book begins to move, so the inequality <math>F \leq \mu R</math> applies until the force wanting to cause motion reaches the limiting value <math>\mu R</math>, called limiting friction.</li> <li>Consider a 10 kg book on a rough horizontal plane. If <math>\mu = 0.5</math>, investigate the value of the frictional force if the pushing force, <math>P</math> is <b>a</b> 10 N, <b>b</b> 98 N, <b>c</b> 100 N</li> <li>Now place the book on an inclined plane and analyse the limiting friction being careful to stress that the reaction force is NOT the weight in this case. Will the book begin to slide for different angles of plane? What is the maximum angle achievable before the book slides?</li> </ul>
Success Criteria	
<ul style="list-style-type: none"> <li><input type="checkbox"/> You can solve problems involving motion on rough or smooth inclined planes.</li> <li><input type="checkbox"/> You can solve problems involving connected particles that require the resolution of forces</li> </ul>	
Assumed Prior Knowledge/ Links / Interleaving	Opportunities for Reasoning/Problem Solving/Proofs
<p>GCSE (9-1) in Mathematics at Higher Tier</p> <ul style="list-style-type: none"> <li>2D trigonometry</li> <li>Cosine and sine rules</li> </ul> <p>AS Mathematics – Pure</p> <ul style="list-style-type: none"> <li><math>\frac{\sin x}{\cos x} = \tan x</math> (to find the angle of the resultant)</li> <li>Basic vectors, magnitude and direction (kinematics)</li> <li><b>i, j</b> vectors</li> <li>Force diagrams and assumptions</li> </ul>	<ul style="list-style-type: none"> <li>Discuss car's braking distances and how the it is determined and then bring the variable of weather and the affect it could have</li> </ul>
	Potential Barriers to Access /Misconceptions
	<ul style="list-style-type: none"> <li>Students are often good at drawing force diagrams, but common errors are omitting arrowheads, incorrectly labelling (e.g. 4 kg rather than 4g) and missing off the normal reaction or friction forces. Students can sometimes struggle to work out the direction of the frictional force.</li> <li>Some students may mistakenly think that the coefficient of friction changes if the mass of an object or the angle of the slope changes.</li> </ul>

<b>Key Mathematical Vocabulary</b>	Force, weight, tension, thrust, friction, coefficient of friction, $\mu$ , limiting, reaction, resultant, magnitude, direction, bearing, force diagram, equilibrium, inextensible, light, negligible, particle, smooth, rough, uniform, perpendicular.	
<b>Personal Development</b>	<b>Notes</b>	<b>Resources</b>
Pupils are taught that they must show 'ambition' in their assignments by attempting to meet all criteria in their homework, with honesty with regards what support they have had to complete the assignment		