A Level Mechanics Question: A Revision Check List

Consider:

- Which question type are we dealing with? Write down the key principle and the key results that apply.
- What does the situation *look* like? Draw a detailed, accurate, large diagram. Fix details such as the direction of motion, friction etc.
- What information are we given? Add everything to the diagram.
- What are the two opposing directions in which information can be gathered? Add resolved forces or velocities to the diagram.
- List knowns, assign variables to unknowns in each direction.
- Generate equations using the key results and solve them.

Hints:

- Try to imagine yourself into the physical situation. It is very helpful to have a feeling for how objects will move (or not move as the case may be).
- If motion is involved form a view on which direction motion will take place. Draw an arrow onto your diagram to show acceleration as positive in that direction. Always resolve forces in this direction and the direction perpendicular to it.
- Form a view of the likely outcome. Make a rough estimate of quantities involved. Use these to check your answer.
- Remember Newton's 3 laws of motion – make sense of them in every question context.

Newton's Laws of Motion

- **First Law**: A body will remain at rest or continue with constant velocity unless a net external force is acting on it.
    - If a body is at rest then any forces that are acting on it, must all be equal and opposite, so if you resolve in any direction, the result will be zero.
    - Be careful that a body can continue moving even if there is no force acting. A good example of this is the horizontal motion of a projectile. There is no horizontal force, so it must continue moving with the same velocity.

Contact: chris@themathszone.co.uk
Visit: www.themathszone.co.uk

- **Second Law**: The acceleration of a body is proportional to the resultant force acting on it.
    - This is the statement that $F = ma$
    - When resolving forces, it is good practice to use $F = ma$ clearly. When a body is at rest it is tempting to write: force 1 = force 2. Using $F = ma$ the situation is force 1- force 2 = 0. This helps prevent errors in interpreting direction.
- **Third Law**: For every action there is an equal an opposite reaction.
    - If a block is at rest on a table, then due to gravity it ought to fall down. Why doesn't it? Because there is an equal and opposite reaction, called the normal contact force (or normal reaction), that prevents it. The third law makes it tempting to always show the normal as always vertical. Since it is due to contact, it must always be perpendicular to the surface. The "equal and opposite" force is the vertical component of the normal which you can find by resolving.

Principles and Results

Question Type	Key Principle(s)	Key Results
Force diagrams	• Newton's three laws of motion • Friction acts in the opposite direction of actual or potential motion. It is equal to μR when the body is moving or on the point of moving. • The normal contact force always acts perpendicular to the surface that the body is in contact with. *Hints*: Draw an arrow to show all of the forces in the situation. Draw a separate arrow to show which direction you expect the motion or possible motion to be. Label this to show positive acceleration. Use a different colour or a new diagram to show resolved components of forces.	$F = ma$ Friction $\leq \mu R$
Projectiles	Consider the horizontal and vertical directions separately. Key points: • The horizontal acceleration is always zero.	$v = u + at$ $v^2 = u^2 + 2as$ $s = ut + \frac{1}{2}at^2$

Contact: chris@themathszone.co.uk

Projectiles (contd.)	• The vertical acceleration is -*g* • At the greatest height, the vertical final velocity is zero. • At the greatest range the vertical displacement is zero. *Hint*: To avoid confusion you can label the horizontal components of the initial and final velocity u_h and v_h.	$v = u + at$ $v^2 = u^2 + 2as$ $s = ut + \frac{1}{2}at^2$
Connected particles Colliding particles	The total momentum in a system is conserved unless an external force acts. An impulse is a force applied over a given (normally short) time.	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ Impulse = $Ft = mv - mu$
Vector kinematics		$v = \frac{dr}{dt}$ $a = \frac{dv}{dt}$ $r = \int v\,dt$
Velocity/time and displacement/time graphs	• The gradient of a graph showing displacement against time gives the velocity. • The area under a graph showing velocity against time gives the displacement. • The gradient of a graph showing velocity against time gives the acceleration.	
Turning - moments (Also: Centres of Mass)	If a system is in equilibrium, the total moment about any point is zero. The centre of mass for a uniform body is its physical centre.	The moment of a force about a fixed point is the magnitude of the force × the perpendicular distance between the line of the force and the point.
Additional principles and formulae:		
Work done		Work done = force × distance
Energy	The **total** energy within a closed system cannot be gained or lost. Remember, that unless energy is lost (e.g. as heat or light) then K.E. + P.E. remains constant.	K.E. = $\frac{1}{2}mv^2$ P.E. = mgh

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