Topic 2 Mechanics: The Study of Motion.
This is divided into Kinematics, which is the study of HOW things move, and Dynamics, which studies WHY things move.

2.1 Kinematics

2.1.1 Define displacement, velocity, speed and acceleration.
NOTE: IB uses u for initial velocity, and s for displacement. Many books use v_o and Δx for those same quantities.

2.1.2 Explain the difference between instantaneous and average values of speed, velocity and acceleration.
(The smaller Δt is the more 'instantaneous' a quantity is.)

2.1.3 Outline the conditions under which the equations for uniformly accelerated motion may be applied.
The kinematic equations

$s = ut + (1/2)at^2$
$v = u + at$
$v^2 = u^2 + 2as$

can only be used if the acceleration *a* is CONSTANT.

2.1.4 Identify the acceleration of a body falling in a vacuum near the Earth's surface with the acceleration *g* of freefall.

2.1.5 Solve problems involving the equations of uniformly accelerated motion.
General:

$s = (u + v)t/2$, same as "distance equals rate x time"
$s = ut + (1/2)at^2$
$v = u + at$
$v^2 = u^2 + 2as$

Freefall: Substitute '-g' for 'a' in all of the above equations.

2.1.6 Describe the effects of air resistance on falling objects.
- Students should know what is meant by terminal speed.
- This is when the drag force exactly balances the weight.

2.1.7 Draw and analyze distance-time graphs, displacement-time graphs, velocity-time graphs and the areas under the velocity-time graphs and acceleration-time graphs.
- The slope of the displacement-time graph is the velocity.
- The slope of the velocity-time graph is the acceleration.
- The area under the velocity-time graph is the total displacement.

2.1.8 Calculate and interpret the gradients (slopes) of displacement-time graphs and velocity-time graphs.
- The (gradient) slope of the displacement-time graph is the velocity.
- The slope of the velocity-time graph is the acceleration.

2.1.9 Determine relative velocity in one and two dimensions.
$v_{ab} = v_a - v_b$. This formula is NOT in the Physics Data Booklet.

2.2 Forces and dynamics

2.2.1 Calculate the weight of a body using the expression W = mg.
Weight W is just a special force. Since weight causes freefall acceleration, F = W, and a = g, so that F = ma becomes W = mg.

2.2.2 Identify the forces acting on an object and draw free-body diagrams representing the forces acting.
(Know normal, tension, friction, weight, drag, and spring forces.)

2.2.3 Determine the resultant force in different situations. $\Sigma F = ma$, or $F_{net} = ma$.

2.2.4 State Newton's First Law of Motion.
An object at rest stays at rest, or an object in uniform motion remains in its state of uniform motion, unless there is a net force applied to it.

2.2.5 Describe examples of Newton's First Law.
Any non-accelerating body, such as a plane traveling in a constant direction at a constant speed, or an object at rest.

2.2.6 State the condition for translational equilibrium.
$\Sigma F = 0$ (not on your Physics Data Booklet).
This could imply no motion, or constant velocity.

2.2.7 Solve problems involving translational equilibrium.
$\Sigma F = 0$, balanced forces.
Note that $\Sigma F = 0$ does not imply the object is standing still.

2.2.8 State Newton's Second Law of Motion.
The acceleration of an object is directly proportional to the applied force, but varies inversely with the mass.
$a = F/m$ or $\Sigma F = ma$ or $F_{net} = ma$.
The momentum form looks like this: $F = \Delta p/\Delta t$ (see 2.2.10).

2.2.9 Solve problems involving Newton's second law.
$\Sigma F = ma$, or $F_{net} = ma$.

2.2.10 Define linear momentum and impulse.
$p = mv$, and
Impulse $= F\Delta t = m\Delta v$ = area under F vs. t graph and
$F_{net} = \Delta p/\Delta t$.

2.2.11 Determine the impulse due to a time-varying force by interpreting a force-time graph.
Impulse is the area under the force-time graph.

2.2.12 State the law of conservation of linear momentum.
In the absence of an external force, momentum is conserved. $P_o = P_f$.

2.2.13 Solve problems involving momentum and impulse.
$p_{ao} + p_{bo} = p_{af} + p_{bf}$ (in general), and
$m_a v_{ao} + m_b v_{bo} = (m_a + m_b)v_f$ (inelastic collision).

2.2.14 State Newton's Third Law of Motion.
For every action there is an equal and opposite reaction.
$F_{ab} = F_{ba}$.

2.2.15 Discuss examples of Newton's Third Law. Students should understand that when two bodies interact, the forces they exert on each other are equal and opposite.

2.3 Work, energy and power

2.3.1 Outline what is meant by work.
$W = Fs \cos \theta$.

2.3.2 Determine the work done by a non-constant force by interpreting a force-displacement graph.

The work done by a force is the area under the force-displacement graph.
For a spring, this is a triangular area.

2.3.3 Solve problems involving the work done by a force.

$W = Fs \cos \theta$.

Don't forget the work-kinetic energy theorem: Work = $\Delta K = \Delta E_K$.

2.3.4 Outline what is meant by kinetic energy.

$E_K = (1/2)mv^2$.

IBO uses E_K for the K used in many textbooks.
In terms of momentum, $E_K = p^2/(2m)$.

2.3.5 Outline what is meant by change in gravitational potential energy.

$\Delta E_P = mg\Delta h$.

IBO uses E_P for the U used in many books for potential energy.

2.3.6 State the principle of conservation of energy.

$\Delta E_K + \Delta E_P = 0$ (as used by IBO)
$K_o + U_o = K_f + U_f$, or
$\Delta K + \Delta U = 0$ or
$\Delta K + \Delta U = W_{nc}$.

(None of these formulas is in the Physics Data Booklet.)

2.3.7 List different forms of energy and describe examples of the transformation of energy from one form to another.

Mechanical (kinetic and potential).
Chemical.
Heat.
Nuclear.

2.3.8 Distinguish between elastic and inelastic collisions.

In elastic collisions kinetic energy is conserved.

2.3.9 Define power.

$P = E/t$, or $P = Fv$.
Power = Work/Time.

2.3.10 Define and apply the concept of efficiency.

Efficiency = E_{out}/E_{in} (not in Physics Data Booklet).

2.3.11 Solve problems involving momentum, work, energy and power.

2.4 Uniform circular motion

2.4.1 Draw a vector diagram to illustrate that the acceleration of a particle moving with constant speed in a circle is directed towards the center of the circle.

2.4.2 Apply the expression for centripetal acceleration.

$a = v^2/r$ or
$a = 4\pi^2 r/T^2$, since $v = 2\pi r/T$
where T is the period of motion (time to go around once).

2.4.3 Identify the force producing circular motion in various situations. Examples include friction of tires on turn, gravity on planet/moon, cord tension.

2.4.4 Solve problems involving circular motion.

Problems of banked roads or banking airplane turns will not be included.

$F_c = ma_c = mv^2/r$

where F_c is the centripetal force and a_c is the centripetal acceleration.