Dynamics Work Scheme (Pilot 2008-9)

Before starting this Advanced (Level 3) FSMQ students are expected to have acquired the skills and knowledge associated with a Functional Mathematics course at Level 2, or equivalent. Candidates will also need knowledge of the following.

Trigonometry: - Use of sin, cos and tan (but not the Sine or Cosine rules)

Algebra: - Collection of like terms and solution of linear equations such as $3 + 5t = 24 - 5t$

- Solution of a quadratic equation by at least one of the following methods: use of graphic calculator, use of formula, factorisation (where appropriate), completion of the square

It is suggested that this FSMQ should be allocated a total of 60 guided learning hours (eg 2 hours per week for 30 weeks, 4 hours per week for 15 weeks, 5 hours per week for 12 weeks). A suggested work scheme showing topics and methods to be covered is given below but the order and time allocations can be varied to suit different groups of students.

Throughout the course students should learn how to use mathematical models to solve problems, making assumptions to create a simple model of a real situation. Experimental or investigational methods should be used to explore how the mathematical model relates to the actual situation. Modelling will include the appreciation that it is appropriate at times to treat relatively large moving bodies as point masses, that the friction law $F = \mu R$ is experimental and that the force of gravity can be assumed to be constant only under certain circumstances. The terms: light, smooth, rough, inextensible, thin and uniform should be introduced as soon as possible and used wherever relevant. Students should be encouraged to comment on the modelling assumptions made including occasions when terms such as particle, light, inextensible string, smooth surface and motion under gravity are used.

Topic Area	Content	Nuffield Resource
Sketching and interpreting kinematics graphs (4 hours)	Find out what students already know about displacement, speed, velocity and acceleration and discuss the difference between vector and scalar quantities. Use gradients and area under graphs to solve problems (N.B. Calculus NOT required). Find average speed and average velocity.	**Model the Motion** Set of 6 cards for learners to match, each set giving a scenario, displacement-time graph and velocity-time graph. PowerPoint presentation includes all of the graphs (animated to aid class discussion).
Motion in 1 dimension with constant acceleration (6 hours)	Use graphs to derive the equations $v = u + at$, $s = ut + \frac{1}{2}at^2$, $s = \frac{1}{2}(u+v)t$, $v^2 = u^2 + 2as$ Solve problems involving the position, velocity, speed and acceleration of a particle moving in one dimension with constant acceleration.	**Constant Acceleration Equations** Worksheet leading learners through the derivation of these equations (with matching Powerpoint presentation)
Vertical motion under gravity (5 hours)	Carry out an experiment to verify Galileo's theory regarding vertical motion. Apply the constant acceleration formulae to vertical motion under gravity with the acceleration due to gravity taken as $9.8\ \text{ms}^{-2}$.	**Falling Ball** Introduces Galileo's claim, shows how to set up a model and gives instructions for an experiment to validate the theory. **Runaway Train** An activity in which students model the motion of a train rolling down a slope with Powerpoint presentation to aid class discussion.

Topic Area	Content	Nuffield Resources
Forces (3 hours)	Introduce forces. Make an elastoscale and use it to measure and investigate forces. Draw force diagrams (identifying those forces present) and clearly label diagrams, distinguishing between forces and other quantities such as velocity. Include force of gravity $W = mg$ with $g = 9.8$ (Newton's Universal Law not required), tensions in strings and rods and resistance.	**Measure Forces** Introduction to forces - includes instructions on how to make and use an elastoscale to measure and investigate forces. **Force Diagrams** Learners show forces acting on a variety of objects in real situations.
Newton's Laws (8 hours)	Introduce Newton's three laws of motion (for a particle of constant mass). Use knowledge that the resultant force is zero to find unknown forces on bodies that are at rest or moving with constant velocity. (Not resolution of forces or components of forces). Apply Newton's second law in the form $F = ma$ to particles moving with constant acceleration. Include finding the acceleration of a body, if the forces acting are specified, or unknown forces if the acceleration is given.	**Newtonian Modelling** Introduces Newton's Laws and provides practice in applying them in a wide range of contexts.
Friction (5 hours)	Carry out an experiment to investigate friction. Discuss limiting friction, the coefficient of friction and the relationship $F = \mu R$ Use $F = \mu R$ as a model for dynamic friction to solve problems involving motion on a rough surface.	**Investigating Friction** Activities to investigate friction leading to summary of main points. **Solve Friction Problems** Set of problems to solve set in real contexts.
Projectiles (8 hours)	Use the equations $x = V\cos\alpha\, t$ and $y = V\sin\alpha\, t - \frac{1}{2}gt^2$ to solve problems involving motion of an object under uniform gravity in a vertical plane. Include the finding initial speed and/or the angle of projection and modification of the equations to take account of the height of release. (N.B. Students will be expected to state the equations and be aware of the assumptions made.) Calculate range, time of flight and maximum height. (N.B. Formulae for the range, time of flight and maximum height should not be quoted in examinations. Also inclined plane and problems involving resistance will not be set and use of the identity $\sin 2\theta = 2\sin\theta\cos\theta$ will not be required.)	**Galileo's Projectile Model** Introduces Galileo's model and includes an experiment that learners can carry out to validate it. The Powerpoint presentation can be used to introduce the activity and aid class discussion about the results. **Projectile Problems** Includes worked examples of typical projectile problems and problems set in real contexts for learners to try.

Topic Area	Content	Nuffield Resources
Momentum (5 hours)	Introduce the concept of momentum (momentum = mv). Apply the principle of conservation of momentum to two particles for direct impacts in one dimension. (N.B. Knowledge of Newton's law of restitution is not required.) Use Force = rate of change of momentum	will be added as they become available
Vectors (8 hours)	Understanding of a vector; its magnitude and direction. Add and subtract vectors, multiply a vector by a scalar. Magnitude and direction of quantities represented by a vector. Solve problems such as finding the time when a particle is at a specified position or has a specified velocity, or finding the position, velocity or acceleration of a particle at a specified time. Use the constant acceleration equations in vector form i.e. using $\mathbf{v} = \mathbf{u} + \mathbf{a}t$, $\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$, $\mathbf{s} = \frac{1}{2}(\mathbf{u} + \mathbf{v})t$ to find the position, velocity, speed and/or acceleration of a particle moving in two dimensions with constant acceleration. (N.B. Examinations questions will be set using the column vector notation and resolution of velocities will not be required.)) Use momentum as a vector in two dimensions. Apply Newton's three laws of motion in two dimensions using vectors	
Revision (8 hours)	Discuss & work through revision questions **Discuss Data Sheet and make up and work questions based on it.**