2.2 Forces impulse and momentum (full A.2)

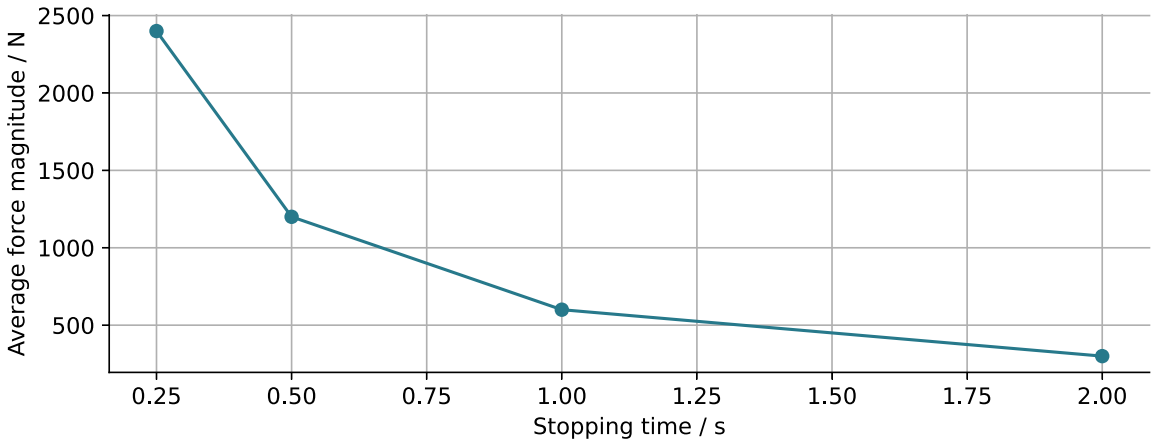
Name: _____ Class: _____ Date: _____ **Total: 25 marks**

KEY WORDS static friction • impulse • translational equilibrium

Objective

Practise the full guide A.2 toolkit beyond the focus lesson: the named contact and field forces with their equations (friction coefficients, Hooke's law, viscous drag, buoyancy, weight), free-body analysis, translational equilibrium, impulse and momentum change, and one-dimensional momentum conservation. Original practice; not an official IB paper.

1 Key knowledge and worked examples



- **The force equations**

$$F_f \leq \mu_s F_N \text{ (static)} \qquad F_f = \mu_d F_N \text{ (moving)} \qquad F_H = -kx$$

$$F_d = 6\pi\eta r v \qquad F_b = \rho V g \qquad F_g = mg$$

- **Second law, both forms**

$$F = ma \ (m \text{ constant}) \qquad F = \frac{\Delta p}{\Delta t} \qquad J = F\Delta t = \Delta p$$

Isolated systems conserve momentum; equilibrium means zero resultant force.

2 Practice

2.1 A 3.0 kg crate rests on the floor ($\mu_s = 0.50$). Calculate the minimum horizontal force to start it moving (g = 9.8 m/s^2). [3]

2.2 A spring stretches 4.0 cm under a 6.0 N load. Calculate the spring constant. [2]

2.3 State Hooke's law and the meaning of the negative sign. [2]

2.4 A 0.20 kg ball moving at 8.0 m/s is stopped in 0.050 s. Calculate the average force. [3]

2.5 State the condition for translational equilibrium. [1]

3 Exam-style questions

3.1 A 1200 kg car travelling at 20 m/s is brought to rest in 0.40 s. Calculate the momentum change, the average braking force, and the distance travelled (assume constant deceleration). [6]

3.2 A 70 kg skater at 3.0 m/s catches a 12 kg ball thrown toward her at 9.0 m/s (opposite direction to her motion). They move together after the catch. Calculate their common velocity, stating the momentum sign convention. [4]

3.3 A small sphere of radius 1.0 mm falls through oil ($\eta = 0.20$ Pa s, $\rho = 900$ kg/m^3). At terminal speed the viscous drag equals the sphere's weight minus the buoyancy. Explain why the sphere reaches a terminal speed and state the force equation at that moment.[4]