A Level Mechanics
Practice Test 1: Kinematics

Instructions:
Answer all questions. Show your working clearly.
Calculators may be used unless stated otherwise.
Draw diagrams where appropriate to illustrate your solutions.
Time allowed: 2 hours 30 minutes

Section A: Kinematic Quantities and Concepts [20 marks]

Question 1 [**8 marks**]

(a) Define displacement and state its SI unit. [**2 marks**]

(b) Define velocity and state its SI unit. [**2 marks**]

(c) Explain the difference between distance and displacement. [**2 marks**]

(d) Explain the difference between speed and velocity. [**2 marks**]

Question 2 [**12 marks**] A particle moves along a straight line. Its position at time t seconds is given by $s = 3t^3 - 12t^2 + 18t$ metres.

(a) Find expressions for the velocity and acceleration of the particle at time t. [**4 marks**]

(b) Calculate the velocity and acceleration when t = 2 seconds. [**3 marks**]

(c) Find the times when the particle is at rest. [**3 marks**]

(d) Calculate the displacement of the particle between t = 0 and t = 3 seconds. [**2 marks**]

Section B: Uniform Acceleration - SUVAT Equations [35 marks]

Question 3 [**10 marks**]

(a) State the five SUVAT equations for motion with constant acceleration. [**5 marks**]

(b) Define each of the symbols used in these equations. [**5 marks**]

Question 4 [**25 marks**] A train accelerates uniformly from rest and reaches a speed of 30 m/s after travelling 450 m.

(a) Calculate the acceleration of the train. [**3 marks**]

(b) Find the time taken to reach 30 m/s. [**3 marks**]

(c) The train then maintains constant speed for 20 seconds before decelerating uniformly to rest over a distance of 200 m. Calculate:

(i) The deceleration during braking. **[4 marks]**

(ii) The time taken to decelerate to rest. **[3 marks]**

(d) Calculate the total distance travelled during the entire journey. **[3 marks]**

(e) Find the total time for the entire journey. **[3 marks]**

(f) Sketch a velocity-time graph for the entire motion, labeling key values. **[6 marks]**

Section C: Motion Under Gravity [30 marks]

Question 5 **[15 marks]** A ball is thrown vertically upward from ground level with an initial velocity of 20 m/s. Take $g = 9.8$ m/s².

(a) Calculate the maximum height reached by the ball. **[4 marks]**

(b) Find the time taken to reach maximum height. **[3 marks]**

(c) Determine the total time of flight. **[3 marks]**

(d) Calculate the velocity of the ball when it returns to ground level. **[2 marks]**

(e) Find the height of the ball after 1.5 seconds. **[3 marks]**

Question 6 **[15 marks]** A stone is dropped from the top of a cliff 60 m high. At the same instant, another stone is thrown vertically upward from the bottom of the cliff with initial velocity 24 m/s.

(a) Write equations for the height of each stone at time t seconds. **[4 marks]**

(b) Find when the stones are at the same height. **[4 marks]**

(c) Calculate the height at which they meet. **[3 marks]**

(d) Determine the velocities of both stones when they are at the same height. **[4 marks]**

Section D: Motion on Inclined Planes [25 marks]

Question 7 **[12 marks]** A particle slides down a smooth inclined plane that makes an angle of 25° with the horizontal.

(a) Show that the acceleration down the plane is $g \sin 25$. **[3 marks]**

(b) If the particle starts from rest and travels 8 m down the plane, calculate its final velocity. **[4 marks]**

(c) Find the time taken to travel this distance. **[3 marks]**

(d) Calculate the speed at which the particle would hit the bottom if the plane is 15 m long. **[2 marks]**

Question 8 **[13 marks]** A car travels up a hill inclined at 10° to the horizontal. The car has an initial velocity of 20 m/s up the slope and decelerates at a rate of 2.5 m/s².

(a) Calculate how far up the slope the car travels before coming to rest. **[4 marks]**

(b) Find the time taken to come to rest. **[3 marks]**

(c) Determine the car's velocity after 6 seconds. **[3 marks]**

(d) If the car then rolls back down the slope with acceleration 1.7 m/s², calculate its speed when it returns to the starting point. **[3 marks]**

Section E: Projectile Motion [40 marks]

Question 9 [**15 marks**]

(a) Explain why projectile motion can be analyzed by considering horizontal and vertical components separately. [**3 marks**]

(b) State the equations for horizontal and vertical motion of a projectile launched at angle with initial speed u. [**6 marks**]

(c) Explain why the horizontal velocity component remains constant during flight. [**3 marks**]

(d) Describe the shape of a projectile's trajectory and explain why. [**3 marks**]

Question 10 [**25 marks**] A football is kicked from ground level with an initial velocity of 25 m/s at an angle of 35° above the horizontal.

(a) Resolve the initial velocity into horizontal and vertical components. [**3 marks**]

(b) Calculate the time of flight. [**4 marks**]

(c) Find the maximum height reached. [**4 marks**]

(d) Determine the horizontal range. [**3 marks**]

(e) Calculate the velocity components when the ball lands. [**3 marks**]

(f) Find the speed and direction of the ball when it lands. [**4 marks**]

(g) Determine the height of the ball after 2.0 seconds. [**2 marks**]

(h) Calculate the horizontal distance travelled after 2.0 seconds. [**2 marks**]

Section F: Advanced Projectile Motion [30 marks]

Question 11 [**18 marks**] A projectile is launched from a height of 12 m above ground level with initial velocity 28 m/s at 40° to the horizontal.

(a) Write equations for the horizontal and vertical position at time t. [**4 marks**]

(b) Calculate when the projectile hits the ground. [**5 marks**]

(c) Find the horizontal distance travelled when it hits the ground. [**3 marks**]

(d) Determine the maximum height above ground level. [**3 marks**]

(e) Calculate the velocity components just before impact. [**3 marks**]

Question 12 [**12 marks**] A basketball is shot toward a hoop that is 3.0 m high and 6.0 m away horizontally. The ball is released from a height of 2.0 m at an angle of 45° to the horizontal.

(a) Find the initial speed required for the ball to pass through the hoop. [**6 marks**]

(b) Calculate the maximum height reached by the ball for this initial speed. [**3 marks**]

(c) Determine the time taken for the ball to reach the hoop. [**3 marks**]

Section G: Relative Motion [20 marks]

Question 13 [**8 marks**]

(a) Define relative velocity. [**2 marks**]

(b) For two objects A and B moving with velocities v_A and v_B in the same direction, write an expression for the velocity of A relative to B. [**2 marks**]

(c) How does this expression change if the objects are moving in opposite directions? [**2 marks**]

(d) Give one practical example where relative motion is important. [**2 marks**]

Question 14 [**12 marks**] Two cars are initially 1500 m apart. Car A travels east at 25 m/s while car B travels west at 20 m/s.

(a) Calculate the relative velocity of car A with respect to car B. [**2 marks**]

(b) Find how long it takes for the cars to meet. [**3 marks**]

(c) Determine how far each car travels before they meet. [**4 marks**]

(d) If car A suddenly accelerates at 1.5 m/s² east while car B maintains constant velocity, calculate their relative velocity after 4 seconds. [**3 marks**]

Physics Data and Formulae

Kinematic Definitions:
Displacement: change in position (vector)
Velocity: rate of change of displacement
Acceleration: rate of change of velocity

SUVAT Equations (constant acceleration):

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$
$$s = \frac{u+v}{2}t$$
$$s = vt - \frac{1}{2}at^2$$

where: s = displacement, u = initial velocity, v = final velocity, a = acceleration, t = time

Projectile Motion:
Horizontal motion: $x = u_x t$ (where $u_x = u\cos\theta$)
Vertical motion: $y = u_y t - \frac{1}{2}gt^2$ (where $u_y = u\sin\theta$)
Horizontal velocity: $v_x = u_x$ (constant)
Vertical velocity: $v_y = u_y - gt$

Motion on Inclined Planes:
Acceleration down smooth plane: $a = g\sin\theta$
Component of weight parallel to plane: $mg\sin\theta$
Component of weight perpendicular to plane: $mg\cos\theta$

Constants:
Acceleration due to gravity: $g = 9.8$ m/s² (downward)

Trigonometric Values:

$\sin 25 = 0.423$, $\cos 25 = 0.906$
$\sin 35 = 0.574$, $\cos 35 = 0.819$
$\sin 40 = 0.643$, $\cos 40 = 0.766$
$\sin 45 = 0.707$, $\cos 45 = 0.707$

END OF TEST

Total marks: 200

Grade boundaries: A* 180, A 160, B 140, C 120, D 100, E 80

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