MOMENTUM

IB Physics HL

Dynamics - Set 1 - Markscheme

A.2-A.4 | First assessment 2025 | Higher Level

Independent examination-style practice material

10 original problems

Task 01 - Pulling a crate at an angle

Paper 1A style | IB code A.2 | Total [1]

Part	Marking guidance	Marks
Answer	B. At limiting equilibrium, F cos30 = 0.400(120 - F sin30), giving F = 45.0 N.	**1**

Task 02 - A block held on an incline

Paper 2 style | IB code A.2 | Total [7]

Part	Marking guidance	Marks
(a)	Shows weight, normal reaction, P parallel to the plane and friction along the plane; recognizes that friction may act in either direction.	**2**
(b)	Uses N = 80 cos30 and limiting friction 0.200N = 13.9 N. Applying equilibrium at impending downward and upward motion gives 26.1 N <= P <= 53.9 N.	**5**

Task 03 - A block connected to a hanging mass

Paper 2 style | IB code A.2 | Total [6]

Part	Marking guidance	Marks
(a)	Friction = 0.250(4.00)(10.0) = 10.0 N. Net driving force = 30.0 - 10.0 = 20.0 N; a = 20.0/7.00 = 2.86 m s^{-2}.	**3**
(b)	For the hanging mass, 30.0 - T = 3.00(2.86), hence T = 21.4 N.	**2**
(c)	The string is inextensible and remains taut (or equivalent).	**1**

Task 04 - The rotational inertia of a pulley

Paper 2 style | IB code A.4 | Total [8]

Part	Marking guidance	Marks
(a)	A non-zero difference in tension is required to provide the torque that angularly accelerates the massive pulley.	**2**
(b)	Uses I = MR^2/2 and alpha = a/R. Combining the two translational equations with (T1-T2)R = I alpha gives a = 2.00 m s^{-2}.	**3**
(c)	For 5.00 kg: T1 = 50.0 - 5.00(2.00) = 40.0 N. For 3.00 kg: T2 = 30.0 + 3.00(2.00) = 36.0 N.	**3**

Task 05 - Speed limits on a banked curve

Paper 2 style | IB code A.2 | Total [8]

Part	Marking guidance	Marks
(a)	At low speed the vehicle tends to slide down the bank, so friction acts up the slope. At high speed it tends to slide up, so friction acts down the slope.	**2**
(b)	Resolving horizontal and vertical forces with f = muN acting up the slope gives v_min = 5.68 m s^{-1}.	**3**
(c)	With limiting friction down the slope, resolving forces gives v_max = 15.7 m s^{-1}.	**3**

Task 06 - Maintaining contact in a vertical loop

Paper 1A style | IB code A.2, A.3 | Total [1]

Part	Marking guidance	Marks
Answer	B. At the limiting case v_top^2 = gR. Energy conservation gives mgh = mg(2R) + mgR/2, hence h = 5R/2.	**1**

Task 07 - Collision followed by sliding

Paper 2 style | IB code A.2, A.3 | Total [8]

Part	Marking guidance	Marks
(a)	Momentum conservation: 2.00(6.00) = 5.00v, so v = 2.40 m s^{-1}.	**2**
(b)	Initial kinetic energy = 36.0 J; final kinetic energy = 14.4 J; dissipated energy = 21.6 J.	**3**
(c)	Frictional deceleration = mu g = 2.00 m s^{-2}. Using 0 = 2.40^2 - 2(2.00)s gives s = 1.44 m.	**3**

Task 08 - A two-dimensional collision

Paper 2 style | IB code A.2 | Total [7]

Part	Marking guidance	Marks
(a)	East momentum gives 0.200(5.00) = 0.300v_Bx, so v_Bx = 3.33 m s^{-1}. North momentum gives 0 = 0.200(2.00) + 0.300v_By, so v_By = -1.33 m s^{-1}.	**4**
(b)	Magnitude = 3.59 m s^{-1}. Direction = arctan(1.33/3.33) = 21.8 degrees south of east.	**3**

Task 09 - A beam supported by a cable

Paper 2 style | IB code A.4 | Total [8]

Part	Marking guidance	Marks
(a)	Moment equilibrium about hinge: (T sin30)(4.00) = 200(2.00) + 500(3.00), giving T = 950 N.	**3**
(b)	Horizontal equilibrium gives hinge component 950 cos30 = 823 N towards the wall. Vertical equilibrium gives R_y + 950 sin30 - 700 = 0, hence R_y = 225 N upward.	**4**
(c)	The unknown hinge-force components have zero moment about the hinge and are eliminated.	**1**

Task 10 - A solid sphere rolling down a slope

Paper 2 style | IB code A.3, A.4 | Total [7]

Part	Marking guidance	Marks
(a)	Uses Mgh = Mv^2/2 + Iomega^2/2 with omega = v/R. Thus Mgh = 7Mv^2/10 and v = sqrt(10gh/7) = 4.14 m s^{-1}.	**3**
(b)	For rolling, a = g sin30/[1 + I/(MR^2)] = 10(0.5)/(1.4) = 3.57 m s^{-2}.	**3**
(c)	Static friction acts up the slope, providing the torque for angular acceleration.	**1**