SPH3UB **Test 2: Motion & Forces** **Name:**

Raw Score: / 35	**Converted Score:**	**Level:**

****A maximum of 2 marks total will be deducted for wrong significant figures or wrong/missing units.****

Part 1: Multiple Choice: ***Write your answer in the grid provided.*** [5]

1.	2.	3.	4.	5.

Part 2: Problem Solving: ***Show all steps in your solving, and all final answers should be written to the correct number of significant figures.***

1. The Joker speeds past Batman on a straight road toward a tunnel located 120.0 m away. At the instant he passes Batman, the Joker is travelling at 5.00 m/s and begins accelerating at a constant rate of 0.200 m/s^2. Batman takes 1.50 s to reach the Batcycle and begin the chase. When Batman begins moving, the Batcycle has an initial velocity of 2.00 m/s and then accelerates at a constant rate. Determine the minimum acceleration Batman must maintain in order to catch the Joker just before the Joker reaches the tunnel.? **[3]**

A solid block of volume (V) and density (p_b) is held completely submerged in water of density (p_w) by a light rope attached to the bottom of a lake.The block is initially stationary, with its top surface at a depth (h) below the water's surface. The density of the block is less than that of water.

The rope is suddenly cut, allowing the block to accelerate upward. Assume water resistance is negligible. Assume the density of freshwater is 1000 kg/m³ and neglect water resistance.

Demonstrate the time it takes for the block to reach the surface is determined by this expression: **[3]**

$$t = \sqrt{\frac{2h\rho_b}{g(\rho_{\cdot} - \rho_b)}}$$

8. A conveyor belt moves horizontally to the right at a constant speed. A box is placed on the belt with an initial velocity to the right that is slower than the belt. The box initially slides along the belt before eventually moving at the same speed.

A student claims:

"Since friction always opposes motion, the frictional force acting on the box must point to the left while the box is moving to the right."

a) Evaluate the student's claim. Explain the direction of friction acting on the box while it is sliding. **[2]**

b) Describe what happens to the frictional force once the box moves at the same constant velocity as the conveyor belt. **[1]**

b) Once the system is brought to rest, Batman activates his boots to prevent the masses from sliding. Determine the minimum coefficient of static friction required between Batman and his incline to keep the system stationary. The other incline remains frictionless. **[2]**

6. Batman is driving the Batmobile at 27.0 m/s when he approaches a circular banked curve with a radius of 48.0 m, inclined at 10.0° to the horizontal.

Batman begins braking 50.0 m before the curve, slowing down at a constant rate of 3.20 m/s². The coefficient of static friction between the tires and the road is 0.550.

a) Determine the speed of the Batmobile as it enters the curve. **[1]**

b) Determine whether Batman can safely negotiate the curve without skidding. **[3]**

c) Calculate the minimum coefficient of static friction required for the Batmobile to safely negotiate the curve at this speed. **[1]**

3. A construction elevator weighing 5400 N is descending when its operator applies the brakes, causing it to slow down at a constant rate of 1.80 m/s². The supporting cable has a maximum tensile strength of 24,000 N. Each construction worker entering the elevator weighs 800 N. Determine the maximum number of workers the elevator can safely carry while slowing down.**[2]**

4. A 200.0 kg wood crate sits in the back of a truck. The coefficients of friction between the crate and the truck at $\mu_s = 0.90$ and $\mu_k = 0.50$. The truck starts off a 20° slope. What is the maximum acceleration up the slope the truck can have without the crate slipping out the back? **[3]**

5. Batman (85.0 kg) stands on an icy rooftop inclined at 10.0° to the horizontal. He is connected by a light rope passing over a frictionless pulley to a 25.0 kg block resting on a second incline angled at 60.0°. Both surfaces are initially frictionless, and the rope has a maximum tensile strength of 250.0 N.

a) Determine the acceleration of the system and whether the rope can withstand the tension. **[3]**

2. Batman has to save Gotham City once again! The Joker placed a dangerous device on top of a 15.0m high building. Batman can only disarm the device from a safe distance away as it will go off if it is being mishandled. Batman can launch an electronic scrambler from 1.0 m off the ground to disable the circuits of the bomb mechanism at 25.0 m/s at an angle of 50.0 degrees to hit the device as it lands on top of it

   a) How far from the building should Batman be standing to launch his device? **[2]**

   b) The Joker has installed a defensive barrier extending 18.0 m above the ground. Determine whether Batman's projectile reaches a sufficient maximum height to pass above the barrier.? **[2]**

   c) The electronic timer of the bomb is shielded by a glass case that requires at least 18.0 m/s of impact speed from Batman's launch device to break the glass. Can Batman's device break through the glass casing? **[2]**