**Applied Maths Higher Level 2020**

**2020 Question 1 (a)**

A car is travelling on a straight level road at a uniform speed of 26 m s–1 when the driver notices a tractor 91.2 m ahead.

The tractor is travelling at a uniform speed of 6 m s–1 in the same direction as the car.

The driver of the car hesitates for *t* seconds before applying the brake.

The maximum deceleration of the car is 5 m s–2.

Find the maximum value of *t* which would avoid a collision between the car and the tractor.

**2020 Question 1 (b)**

A 60 gram mass is projected vertically upwards with an initial speed of 15 m s–1 and half a second later a 40 gram mass is projected vertically upwards from the same point with an initial speed of 22.65 m s–1.

1. Calculate the height at which the masses will collide.
2. The masses coalesce on colliding.

Find the greatest height which the combined mass will reach.

**2020 Question 3 (a)**

A particle is projected from a point *P* with speed *u* m s–1 at an angle *α* to the horizontal.

1. Show that the range of the particle is
2. The particle is 24.5 m above the horizontal ground after 5 seconds and it strikes the ground 235.2 m from *P*.

Find the value of *u*.

**2020 Question 4 (a)**

A block A of mass 10*m* on a smooth plane inclined at an angle *α* with the horizontal, where tan *α* = , is connected by a light inextensible string which passes over a smooth pulley to a second block B of mass 10*m*.

B is 24.5 cm above an inelastic horizontal floor, as shown in the diagram.

The system is released from rest.

Find

1. the acceleration of B
2. the time that B remains in contact with the floor.

**2020 Question 4 (b)**

A particle C of mass 2*m* rests on a rough plane which is inclined at 30° to the horizontal.

The coefficient of friction between C and the plane is .
A light inextensible string which passes under a smooth movable pulley of mass 3*m* connects C to a particle D of mass *m*, as shown in the diagram.

The system is released from rest. C moves up the plane.

1. Show, on separate diagrams, the forces acting on the moveable pulley and on each of the masses.
2. Find in terms of *m* the tension in the string.

**2020 Question 5 (a)**

A smooth sphere A of mass *m*, moving with speed 3*u* on a smooth horizontal table collides directly with a smooth sphere B of mass 2*m*, moving in the opposite direction with speed *u*.

The directions of motion of A and B are reversed by the collision.

The coefficient of restitution between A and B is *e*.

1. Find the speed, in terms of *u* and *e*, of each sphere after the collision.

Subsequently B hits a wall at right angles to the line of motion of A and B.

The coefficient of restitution between B and the wall is .

1. After B rebounds from the wall there is a further collision between A and B.

Show that



**2020 Question 5 (b)**

A smooth sphere P has mass *m*1 and speed *u*.

It collides obliquely with a smooth sphere Q, of mass *m*2, which is at rest.

Before the collision the direction of P makes an angle of 30° to the line of centres, as shown in the diagram.

The coefficient of restitution between the spheres is 𝑒.

Prove that P will turn through a right‐angle if 4𝑚1 = (3*e* - 1)m2.

**2020 Question 6 (b)**

A particle P is attached to one end of a light inextensible string of length 𝑑.

The other end of the string is attached to a fixed point *O*.

The particle is hanging freely at rest, with the string vertical, when it is projected horizontally with speed .

The particle moves in a vertical circle.

The string becomes slack when P is at the point *B*.

*OB* makes an angle 𝜃 with the upward vertical.

1. Show that cos 𝜃 = .
2. In terms of 𝑑, find the greatest height of P above *B* in the subsequent motion.

**2020 Question 10 (a)**

One method of dyeing a piece of cloth is to immerse it in a container which has *P* grams of dye dissolved in a fixed volume of water.

The cloth absorbs the dye at a rate proportional to the mass of dye remaining.

where *t* is time in seconds, *x* is the mass of dye absorbed by the cloth and *k* = .

1. Find the time taken to dye a piece of cloth if a mass of 𝑃 needs to be absorbed to reach the desired colour.

(Note: )

1. An alternative method is to keep the mass of dye present in the water constant at *P* grams by continuously adding dye throughout the process.

Find the time taken to dye the piece of cloth to the desired colour using this method.

**2020 Question 10 (b)**

A particle P travelling in a straight line has a deceleration of 4*v*n+1 m s–2, where *n* (> 0) is a constant and *v* is its speed at time *t* (> 0).

P has an initial speed of *u*.

1. Find an expression for *v* in terms of *u*, *n* and *t*.
2. When *n* = 3 obtain an expression for the speed of P when it has travelled a distance of 3 m from its initial position.