**Applied Maths Higher Level 2022**

**2022 Question 1 (a)**

A train takes 40 minutes to travel from rest at station A to rest at station B. The distance between the stations is 20 km. The train left station A at 10:00.

At 10:15 the speed of the train was 32 km h–1 and at 10:30 the speed was 48 km h–1.

The speed of 48 km h–1 was maintained until the brakes were applied, causing a uniform deceleration which brought the train to rest at B.

During the first and second 15‐minute intervals the accelerations were constant.

1. Draw a speed‐time graph of the motion.
2. Find the time taken for the first 16 km.
3. Find the deceleration of the train.

**2022 Question 1 (b)**

A ball *E* is thrown vertically upwards with a speed of 42 m s–1.

𝑇 (< 8) seconds later another ball, *F*, is thrown vertically upwards from the same point with the same initial speed.

1. Find where ball *E* is after 5 s and the total distance it has travelled in this time.
2. Prove that when *E* and *F* collide, they will each be travelling with speed **½𝑔𝑇**.

**2022 Question 3 (a)**

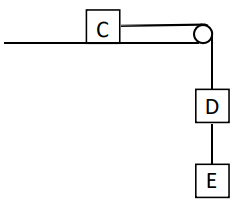
A particle is projected out to sea from a point P on a cliff to hit a target 60 m horizontally from P and 60 m vertically below P.

The velocity of projection is 14√3 m s–1 at an angle *𝛼* to the horizontal.

Find

1. the two possible values of *𝛼*
2. the times of flight.

**2022 Question 4 (a)**

A block C of mass 6m rests on a rough horizontal table.

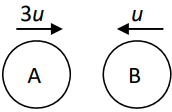
It is connected by a light inextensible string which passes over a smooth fixed pulley at the edge of the table to a block D of mass 3m. D is connected by another light inextensible string to a block E of mass 2m, as shown in the diagram.

The coefficient of friction between C and the table is .

The system is released from rest.

1. Show on separate diagrams the forces acting on each block.
2. Find the acceleration of C.
3. Find the tension in each string.

**2022 Question 5 (a)**

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

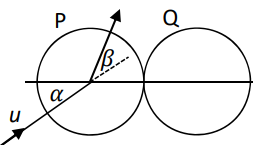
The coefficient of restitution between A and B is *e*.

Find, in terms of *u* and *e*,

1. the speed of each sphere after the collision
2. the magnitude of the impulse imparted to B due to the collision.
3. The loss of the kinetic energy due to the collision is *kmu*2(1 – *e*2).

Find the value of k.

**2022 Question 5 (b)**

A smooth sphere P has mass *m* and speed *u*. It collides obliquely with a smooth sphere Q, of mass *m*, which is at rest. Before the collision, the direction of P makes an angle 𝛼 with the line of centres, as shown in the diagram.

The coefficient of restitution between the spheres is .

During the impact the direction of motion of P is turned through an angle 𝛽.

Show that tan β =

**2022 Question 6 (b)**

A particle is attached to one end of a light inextensible string of length 0.5 m. The other end of the string is attached to a fixed point C. The particle moves in a vertical circle.

The greatest and least tensions in the string are 3*T* and *T*, respectively.

Find the speed of the particle at the lowest point.

**2022 Question 10 (a)**

A particle moves in a horizontal line such that its speed 𝑣 at time 𝑡 is given by the differential equation



1. Given that 𝑣 = 2 when t = 0, find an expression for 𝑣 in terms of 𝑡.
2. Find the minimum value of 𝑣.
3. Find the distance travelled by the particle before it attains its minimum speed.

**2022 Question 10 (b)**

The rate of decay at any instant of a radioactive substance is proportional to the amount of the substance remaining at that instant. The initial amount of the radioactive substance is 𝑁 and the amount remaining after time 𝑡 (hours) is 𝑥.

1. Prove that 𝑥 = Ne-kt, where 𝑘 is a constant.
2. If the initial amount 𝑁 was reduced to in 14 hours, find the value of 𝑘.
3. If the amount remaining is reduced from to in 𝑡 hours, find the value of 𝑡.