1. The engine of a high speed train, travelling at 50 ms^{-1}, delivers a power of 2 MW.

What is the force exerted by the engine?

A 4×10^4 N

B 1×10^5 N

C 4×10^7 N

D 1×10^8 N

Your answer ☐

2. A force of 1000 N is needed to lift the hook of a crane at a constant velocity. The crane is then used to lift a load of 10000 N at a velocity of 0.50 ms^{-1}.

How much power does the motor of the crane need to develop to lift the hook and load?

A 5.0 kW

B 5.5 kW

C 20 kW

D 22 kW

Your answer ☐

3 **a** Define work done by a force.

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.... (*1 mark*)

b Figure 1a shows a ball of mass 200 g on a smooth curved ramp. The ramp rests on a rough horizontal floor. The ball is at rest at a height of 0.65 m above the floor.

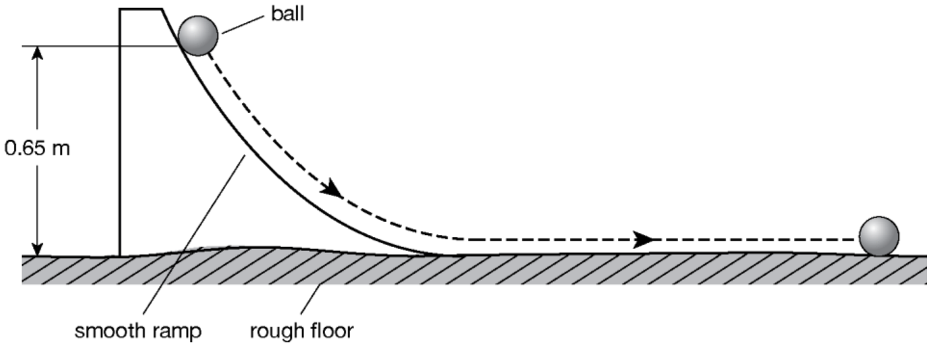

Figure 1a

The ball is released and rolls down the ramp onto the floor before coming to a halt.

i Determine the horizontal distance travelled along the floor, assuming that the average frictional force acting between the ball and the floor is 0.72 N.

distance = ... m (*2 marks*)

ii Describe the energy changes that take place during the motion of the ball.

....

....

.... (*2 marks*)

c A trolley of mass 80 kg is being pulled by along a horizontal path. Figure 1b shows the force, *T*, exerted on the trolley and the frictional force, *F*, acting between the trolley and the path.

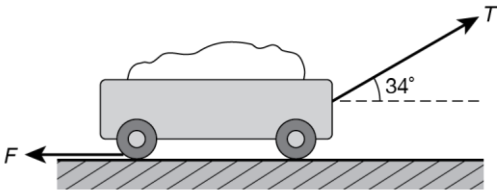

Figure 1b

i In order to keep the trolley moving at a constant speed of 0.85 m s^{-1}, a force of 120 N is exerted at an angle of 34° to the horizontal. Calculate the frictional force, *F*.

F = ... N (*1 mark*)

ii Calculate the work done to pull the trolley a distance of 75 m.

work done = ... J (*1 mark*)

iii After travelling 75 m, the trolley is no longer pulled. Explain why the trolley continues to roll forward and calculate the distance you would expect the trolley to travel. State any assumptions you have made in determining this distance.

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.... (*4 marks*)

4 Figure 2 shows the graph of velocity against time for a lorry of mass 7.0×10^3 kg travelling on a horizontal straight road.

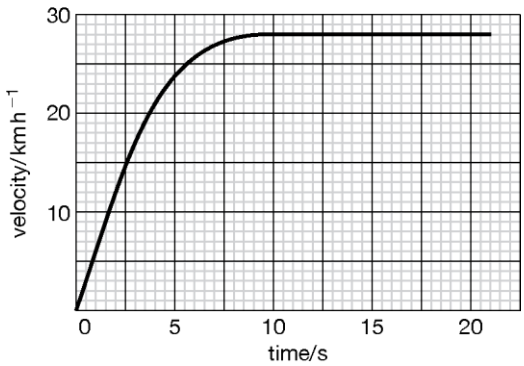

Figure 2

a Describe, without calculation, how the resultant force acting on the lorry varies during the first 20 s of motion.

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....

.... (*2 marks*)

b Calculate the maximum kinetic energy of the lorry.

E_k = ... J (*3 marks*)

c When the lorry is travelling at its maximum velocity the engine is producing 25 kW of useful power. Calculate the driving force created by the lorry to maintain this velocity.

force = ... N (*2 marks*)

d The lorry reaches a hill inclined at an angle of 2° to the horizontal. The driver wishes to continue at the same speed up the hill. Determine the increase in useful power that must be created by the lorry to achieve this result.

power = ... kW (*3 marks*)

5 A builder uses a pulley to raise a trolley of mass 45 kg through a height of 3.2 m.

a Determine the work done by the builder.

work done = ... J (*1 mark*)

b A colleague suggests that the builder would use less energy if they pulled the trolley up an inclined ramp rather than lifting it vertically. Discuss two reasons why this advice is incorrect.

Figure 3 shows both methods of lifting the trolley.

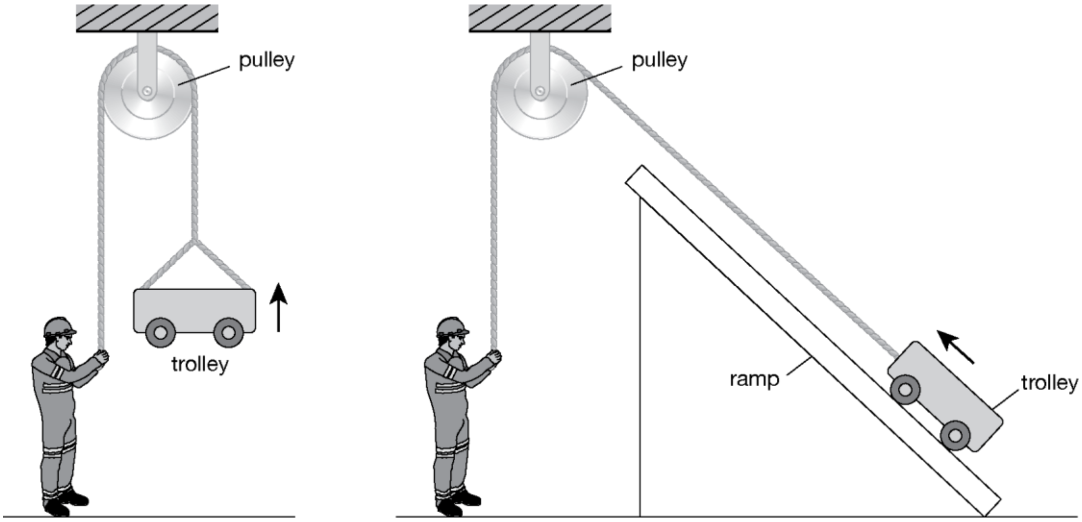

Figure 3

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.... (*2 marks*)

6 Figure 4 shows a sphere hanging at rest from a light thread attached to a newtonmeter.

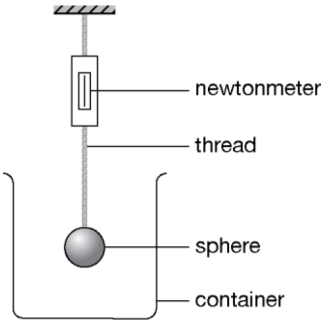

Figure 4

The reading on the newtonmeter is 0.75 N. The container is now filled to the top with oil.

a Explain why the newtonmeter reading is now 0.60 N.

....

.... (*1 mark*)

b The thread is now cut, releasing the sphere. Calculate the initial acceleration of the sphere.

acceleration = ... m s^{-2} (*2 marks*)

c After a short time, the sphere falls at a constant speed equal to 4.2 cm s^{-1}. Explain why the sphere has constant kinetic energy despite continually losing gravitational potential energy during its descent through the oil.

....

.... (*1 mark*)

7 Figure 5 shows a carriage at the start, **A**, of a roller coaster ride.

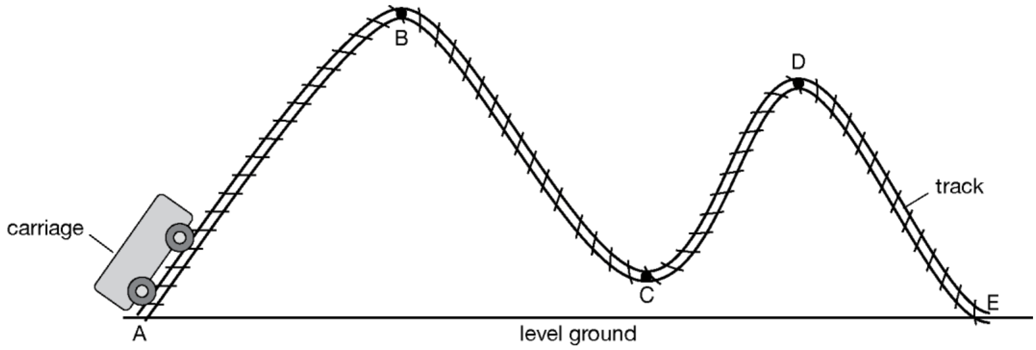

Figure 5

The carriage is pulled up to the highest point, **B** by an electric motor and then released to follow the track **BCDE**. The point **B** is 40 m above the ground; **C** is 5 m, and **D** is 20 m above the ground. The ride is tested using an empty carriage of mass 750 kg.

a Calculate the gravitational potential energy of the empty carriage at **B**.

E_p = ... J (*1 mark*)

b Calculate the maximum velocity of the empty carriage at **D**.

v_{max} = ... m s^{-1} (*3 marks*)

c The actual velocity of the carriage at **D** is less than the value calculated in part **b**. Explain the reason for this discrepancy by considering the energy changes that take place from **B** to **D**.

....

.... (*1 mark*)

d Suggest how you would expect your answers to parts **a** and **b** to be affected if the carriage were to be fully occupied with people.

....

....

.... (*2 marks*)

e The electric motor used to raise the carriage from **A** to **B** has a maximum useful power output of 11 kW and completes the lift in 1.0 minute. Determine the maximum number of people, of average mass 70 kg, that can be allowed in the carriage if the motor is to operate normally.

number of people = ... (*4 marks*)

8 An electric motor can be used to slowly lift a load. An engineer wishes to investigate how the efficiency of the motor varies with the load that it is lifting. The electrical power used by the motor can be determined by connecting a wattmeter between the power supply and the motor, as shown in Figure 6.

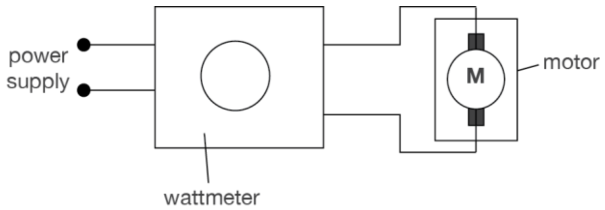

Figure 6

a Describe how you would determine the useful mechanical power output from the motor.

....

....

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.... (*3 marks*)

b Describe how you would determine how the motor's efficiency varies as the load is increased.

....

....

....

.... (*3 marks*)

9 **a** Starting with the definition of *work done*, show that *power* = *force* × *velocity*.

(*1 mark*)

b The motor of a radio-controlled car of mass 490 g has a mechanical power output of 8.0 W when the car is travelling at a constant speed of 7.0 m s^{-1}. Calculate:

i the driving force generated by the motor

driving force = ... N (*1 mark*)

ii the total resistive force acting on the car

resistive force = ... N (*1 mark*)

iii the electrical power used by the motor, assuming it operates with an overall efficiency of 72%.

power = ... W (*2 marks*)

c Theory suggests that drag on a vehicle is proportional to the speed^2. Modification to the vehicle's engine increases the maximum driving force by 12%. Determine the expected increase in maximum speed as a result of this modification.

increase in maximum speed = ... % (*3 marks*)