ME = Ek + Ep	$\frac{1}{2}k_s x^2$	$\frac{1}{2}mv^2$	mgh

*For the entirety of the exam, consider nonconservative forces absent.

1. Define the terms below (5,000 marks):
    a. Mechanical Energy

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    b. Elastic Potential Energy

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    c. Open system

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    d. Gravitational Potential Energy

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2. Explain how a car engine works. Make sure to describe the energy changes that happen in the process. (2,000 marks):

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3. What is the theorem of Kinetic Energy? (2,000 marks)

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4. A 3kg computer monitor is placed on a 1.2m high table. Calculate its Gravitational Potential Energy (1,000 marks):

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5. Rockets will go as fast as 7.9kms^{-1}. If their mass is about 1,000,000kg, calculate their maximum Kinetic Energy. (1,000 marks)

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6. A spring with an elastic constant of 650Nm^{-1} is stretched by 300mm. Calculate the energy stored in that spring. (1,000 marks)

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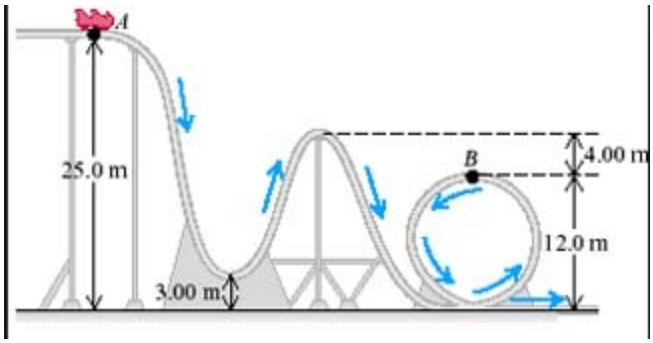
7. The first section of a roller coaster is described by the diagram below (6,000 marks):



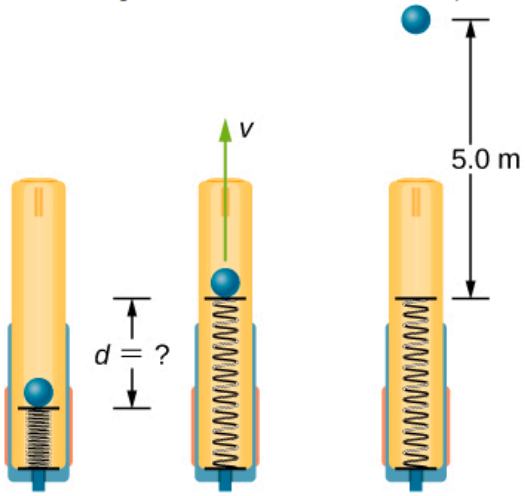
The car is initially at rest at Point A, and just slightly tips over so that it starts moving.

a. Calculate the cart's top speed.

b. Calculate the cart's speed at Point B.

8. A ball is launched from a spring as described by the diagram below (4,000 marks):

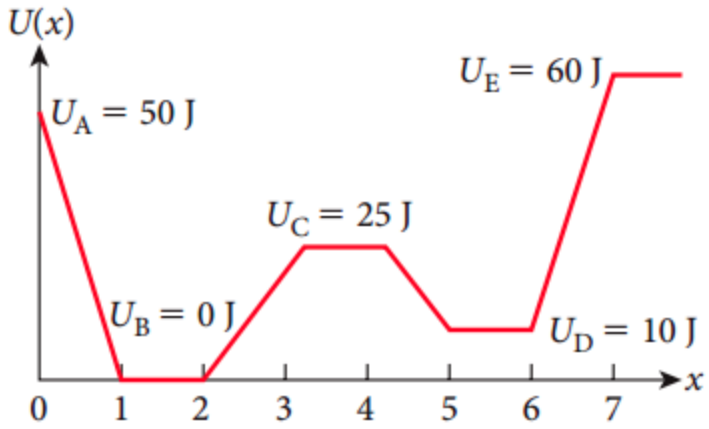
The massless spring of a spring gun has a force constant $k = 12\ \text{N/cm}$. When the gun is aimed vertically, a 15-g projectile is shot to a height of 5.0 m above the end of the expanded spring. (See below.) How much was the spring compressed initially?



a. How much was the spring compressed by?

a. Calculate the ball's speed as it leaves the spring.

9. (5,000 marks) A 520g particle is moving along the x-axis, subject to the potential energy function shown in the figure. If the particle has mechanical energy equal to 30J, determine:



a) The particle's speed when it's potential energy equals 10J.

b) Find the particle's potential energy when it's speed is equal to $8ms^{-1}$.

c) Find the particle's turning points.

2. (18,000 marks)

Mechanical power

(a) Define *power*.

.....

.....

(1)

(b) A car is travelling with constant speed v along a horizontal straight road. There is a total resistive force F acting on the car.

Deduce that the power P to overcome the force F is $P = Fv$.

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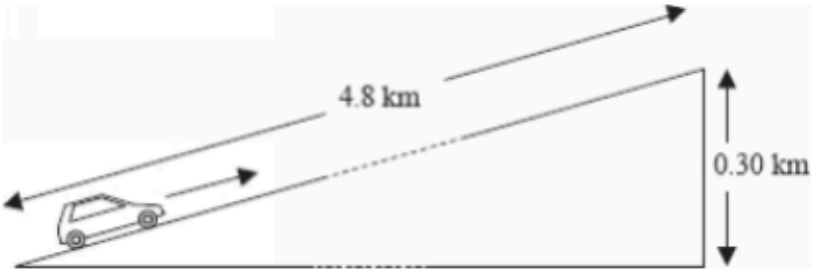
(2)

(c) A car drives up a straight incline that is 4.8 km long. The total height of the incline is 0.30 km.



The car moves up the incline at a steady speed of 16 m s^{-1}. During the climb, the average friction force acting on the car is 5.0×10^2 N. The total weight of the car and the driver is 1.2×10^4 N.

(i) Determine the time it takes the car to travel from the bottom to the top of the incline.

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.....

(2)

(ii) Determine the work done against the gravitational force in travelling from the bottom to the top of the incline.

.....

(1)

(iii) Using your answers to (c)(i) and (c)(ii), calculate a value for the minimum power output of the car engine needed to move the car from the bottom to the top of the incline.

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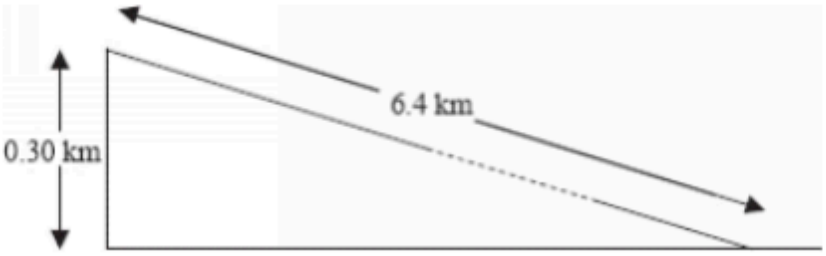
(4)

(d) From the top of the incline, the road continues downwards in a straight line. At the point where the road starts to go downwards, the driver of the car in (c), stops the car to look at the view. In continuing his journey, the driver decides to save fuel. He switches off the engine and allows the car to move freely down the hill. The car descends a height of 0.30 km in a distance of 6.4 km before levelling out.



The average resistive force acting on the car is 5.0×10^2 N.

Estimate

(i) the acceleration of the car down the incline.

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(5)

(ii) the speed of the car at the bottom of the incline.

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(2)

(e) In fact, for the last few hundred metres of its journey down the hill, the car travels at constant speed. State the value of the frictional force acting on the car whilst it is moving at constant speed.

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(1)

(Total 18 marks)