

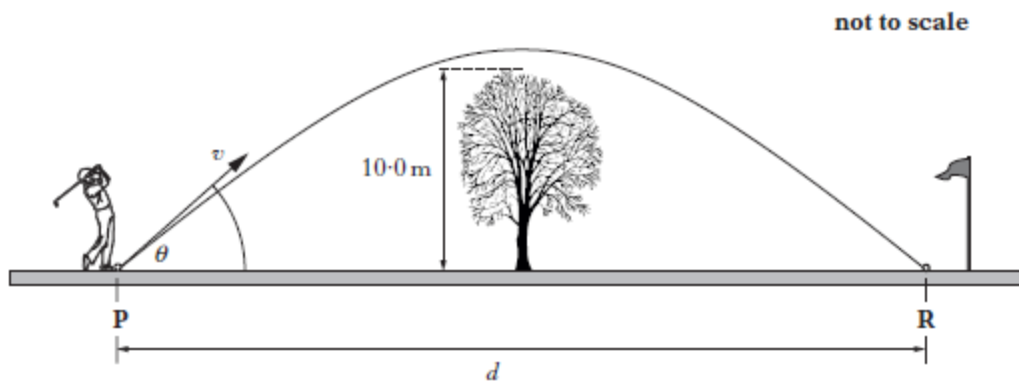
Motion Equations and Graphs – 9 Marks

1.

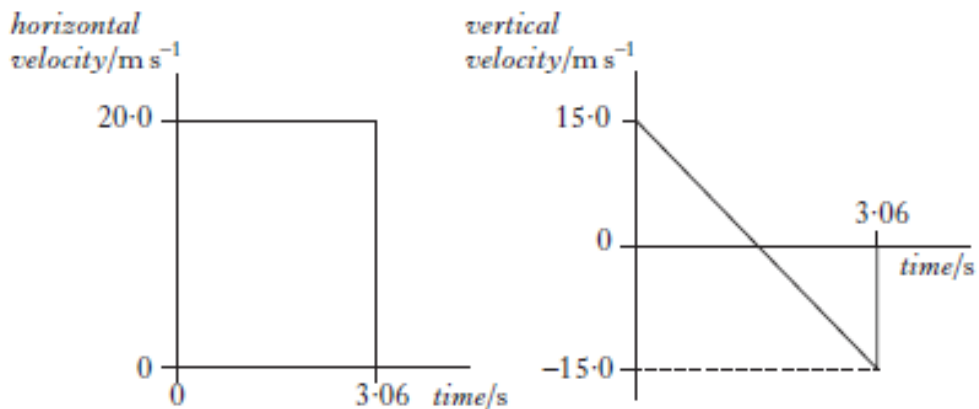
A golfer hits a ball from point **P**. The ball leaves the club with a velocity v at an angle of θ to the horizontal.

The ball travels through the air and lands at point **R**.

Midway between **P** and **R** there is a tree of height 10.0 m.



- (a) The horizontal and vertical components of the ball's velocity during its flight are shown.



The effects of air resistance can be ignored.

Calculate:

- (i) the horizontal distance d ;
- (ii) the maximum height of the ball above the ground.

3
3

- (b) When the effects of air resistance are **not** ignored, the golf ball follows a different path.

Is the ball more or less likely to hit the tree?

You must justify your answer.

3

Forces, Energy and Power -13 Marks

2.

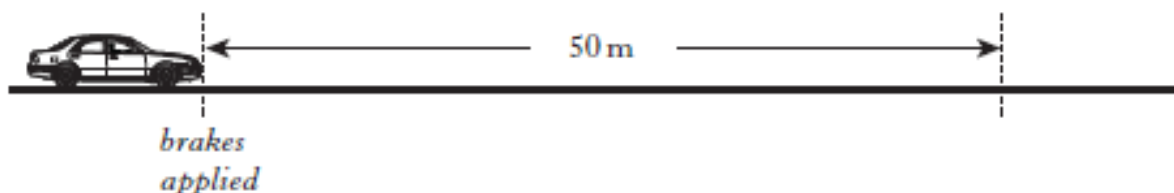
An electric cart and driver accelerate up a slope. The slope is at an angle of 3.2° to the horizontal. The combined mass of the cart and driver is 220 kg.



- (a) (i) Show that the component of the weight of the cart and driver acting down the slope is 120 N. 2
- (ii) At one point on the slope the driving force produced by the cart's motor is 230 N and at this point the total frictional force acting on the cart and driver is 48 N.
Calculate the acceleration of the cart and the driver at this point. 4
- (iii) Explain, in terms of the forces, why there is a maximum angle of slope that the cart can ascend. 2

3.

A car is travelling along a straight, level road. The brakes are then applied and the car comes to rest in a distance of 50 m.



The work done in stopping the car is 75 kJ and the average external frictional force exerted on the car is 300 N.

The total mass of the car and driver is 1100 kg.

(a) Calculate the average force exerted by the brakes on the car.

3

(b) A second car of smaller total mass is travelling at the same speed along the same road. Its brakes are applied and it stops in the same distance of 50 m.

The same average external frictional force is exerted on this car.

How does the value of the average braking force on this car compare to that of the original car?

You must justify your answer.

2

Collisions, Explosions and Impulse – 9 Marks

4.

A picture of a helmet designed to be worn when riding a bicycle is shown.

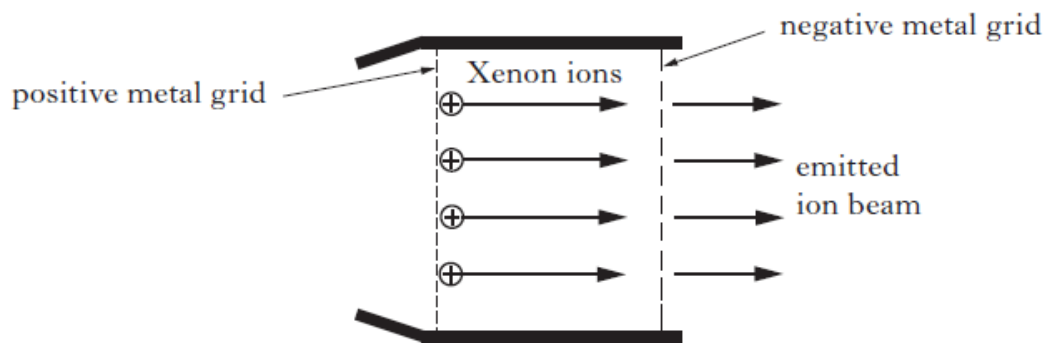


The bicycle helmet has a hard outer shell and a soft expanded polystyrene foam liner.

Using your knowledge of physics, comment on the suitability of this design for a bicycle helmet.

3

5. An ion propulsion engine can be used to propel spacecraft to areas of deep space. A simplified diagram of a Xenon ion engine is shown.



The Xenon ions are accelerated as they pass through an electric field between the charged metal grids. The emitted ion beam causes a force on the spacecraft in the opposite direction.

The spacecraft has a total mass of 750 kg.

The mass of a Xenon ion is 2.18×10^{-25} kg and its charge is 1.60×10^{-19} C. The potential difference between the charged metal grids is 1.22 kV.

a)

The ion beam exerts a constant force of 0.070 N on the spacecraft. Calculate the change in speed of the spacecraft during a 60 second period of time.

3

b)

A different ion propulsion engine uses Krypton ions which have a smaller mass than Xenon ions. The Krypton engine emits the same number of ions per second at the same speed as the Xenon engine.

Which of the two engines produces a greater force?

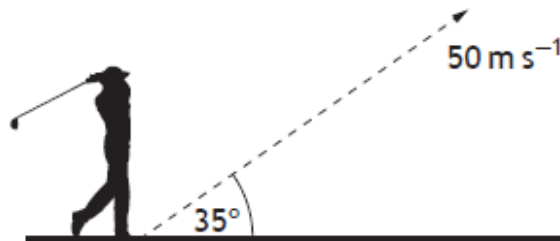
Justify your answer.

3

Gravitation, Gravity and Mass -2 Marks

6.

A golf ball is hit with a velocity of 50.0 m s^{-1} at an angle of 35° to the horizontal as shown.

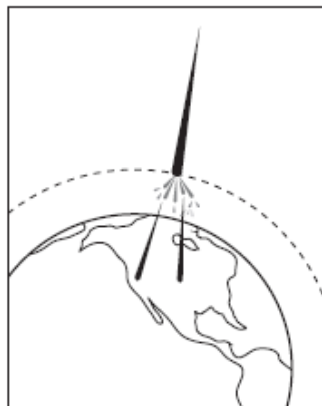


(a) (i) Calculate the horizontal component of the initial velocity of the ball. 1

(ii) Calculate the vertical component of the initial velocity of the ball. 1

Special Relativity – 6 Marks

7. Muons are sub-atomic particles produced when cosmic rays enter the atmosphere about 10 km above the surface of the Earth.



Muons have a mean lifetime of $2.2 \times 10^{-6} \text{ s}$ in their frame of reference. Muons are travelling at $0.995c$ relative to an observer on Earth.

(a) Show that the mean distance travelled by the muons in their frame of reference is 660 m. 2

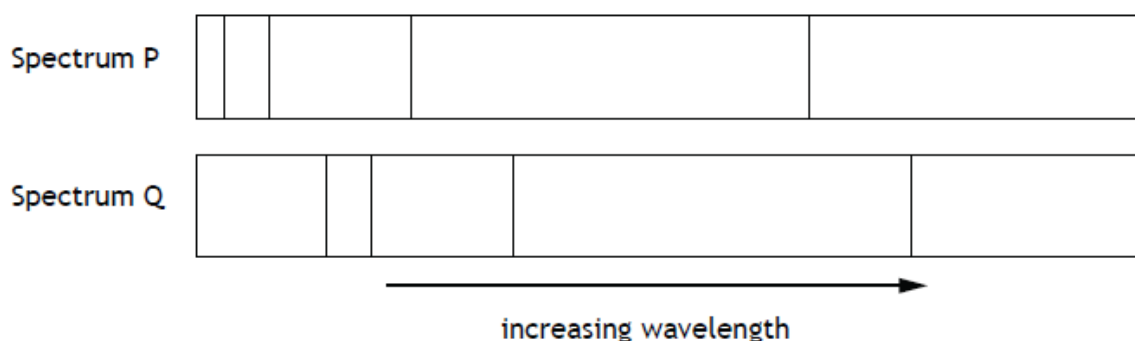
(b) Calculate the mean lifetime of the muons as measured by the observer on Earth. 3

- (c) Explain why a greater number of muons are detected on the surface of the Earth than would be expected if relativistic effects were not taken into account.

1

The Expanding Universe and the Big Bang Theory – 9 Marks

8.



Spectrum P is from a laboratory source.

Spectrum Q shows the equivalent lines from a distant star as observed on the Earth.

- (i) Explain why spectrum Q is redshifted. 2
- (ii) One of the lines in spectrum P has a wavelength of 656 nm. The equivalent line in spectrum Q is measured to have a wavelength of 676 nm.
Calculate the recessional velocity of the star. 5
- (b) The recessional velocity of a distant galaxy is $1.2 \times 10^7 \text{ m s}^{-1}$.
Show that the approximate distance to this galaxy is $5.2 \times 10^{24} \text{ m}$. 2