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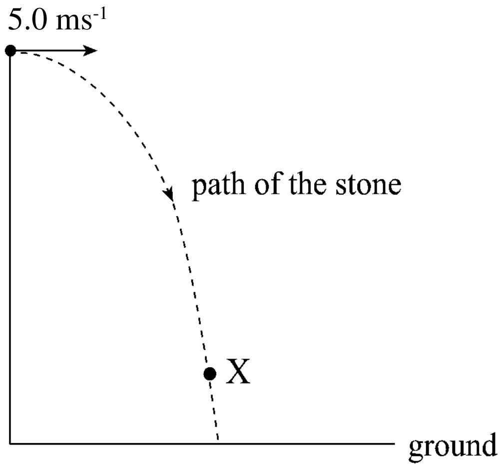
Year 12 Physics

Test: Topics 1-3

Projectile Motion, Circular Motion, Gravitation and Satellites

1. A stone is thrown from a position near the surface of the Earth with an initial horizontal velocity of 5.0 ms^{-1}, as shown in the diagram below. The vertical component of the velocity of the stone at point X is 6.0 ms^{-1}. *Ignore the effect of air resistance.*



(a) Draw a vector on the diagram above showing the direction of the acceleration of the stone at point X. (1)

(b) Draw and label a vector diagram to show the addition of the horizontal and vertical components of velocity of the stone at the instant it reaches point X.
(The diagram does not have to be drawn to scale.)

(2)

(c) Calculate the magnitude and direction of the velocity of the stone at point X.

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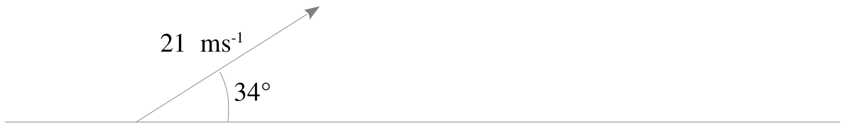
____ (3)

2. A projectile is launched from ground at an angle of 34° with a speed of 21 ms^{-1}.



(a) Calculate the initial vertical and horizontal components of the projectile's velocity.

(2)

(b) Calculate the time of flight of the projectile.

(3)

(c) Hence calculate the range of the projectile.

(2)

(d) Calculate the maximum height reached by the projectile.

(2)

3.

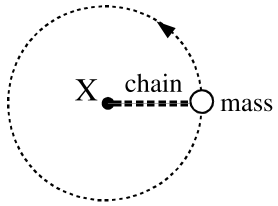
(a) Describe and explain the effect that increasing the launch height of a shot-put has on the maximum range.

____ (3)

(b) State one difference between a shot-put and a tennis ball and describe how it affects the force of air resistance.

____ (2)

4. A mass of 16g is in uniform circular motion on a chain around point X as shown below. The radius of the circle of motion is 12 cm, and the period of motion is 1.2 s.



(a) Identify the force providing the centripetal acceleration for the mass.

____ (1)

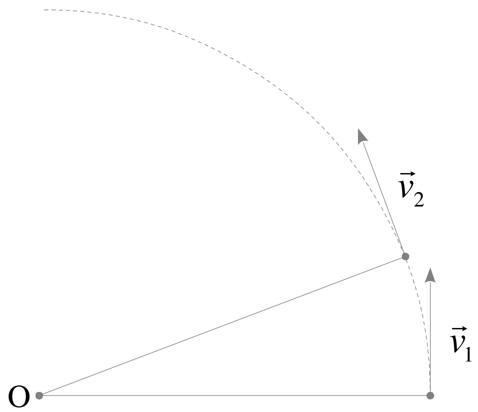
(b) Calculate the speed of the mass.

____ (2)

(c) Calculate the magnitude of the centripetal force.

____ (3)

5. The velocity of a particle moving with uniform circular motion about O is shown at two positions in the diagram below:



(a)

(i) On the diagram above, use the velocity vectors $\vec{v}_1$ and $\vec{v}_2$ to draw a labelled vector diagram showing the change in velocity $\Delta\vec{v}$ of the particle. (2)

(ii) Comment on the direction of the change in velocity $\Delta\vec{v}$.

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(b) Hence state and explain the direction of the instantaneous acceleration of the particle.

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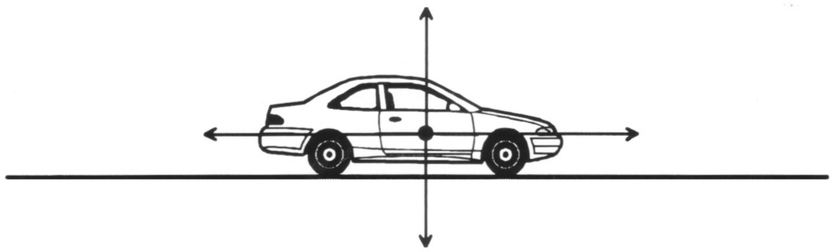
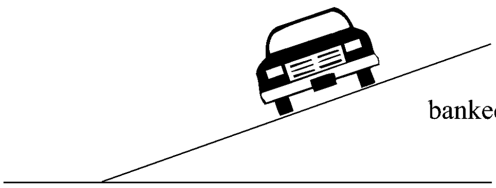
6. Below is a diagram of a car driving with constant velocity to the right along a flat horizontal road. Label the four forces acting on the car.



(2)

7. A car travelling with uniform circular motion around a banked curve on a road is shown in the diagram below. The car is able to travel around the curve without relying on friction.



(a) On the diagram above, draw and label a vector to show the normal force acting on the car.

(1)

(b) Using the vector you have drawn in part (a), explain how the banking angle enables the car to travel around the curve in the road without relying on friction.

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______________________________________ (3)

(c) The curved section of the road has a radius of 150 m and a banking angle of 11°. Calculate the speed at which the car can travel around the curve without relying on friction.

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______________________________________ (2)

8. The diagram below shows a 'binary system', which arises when a star orbits another star.

[This diagram is not drawn to scale.]

(a) On the diagram above, draw vectors to show the gravitational forces acting on the two stars. (2)

(b) Explain why Newton's law of universal gravitation is consistent with Newton's third law of motion.

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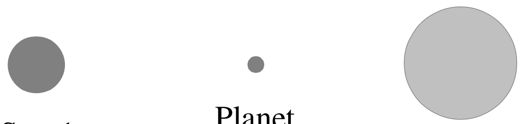
____ (3)

(c) Consider a planet positioned exactly halfway between the centre of masses of the two stars, as shown below:



[This diagram is not drawn to scale.]

Star 2 has double the mass of Star 1, and the force on Planet due to Star 1 is 3.9×10^{22} N. Using proportionality, determine the force on Planet due to Star 2.

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9. Two satellites, A and B, orbit Earth. Satellite A orbits at a radius of 2.112×10^{7} m. Satellite B orbits at a radius of 4.224×10^{7} m and at a speed of 3072 ms^{-1}.

(a) Show that the speed v of a satellite moving in an orbit of radius r around a planet of mass M is given by $v = \sqrt{\frac{GM}{r}}$.

____ (3)

(b) Hence show that the mass of the Earth is approximately 5.98×10^{24} kg.

____ (2)

(c) Calculate the orbital speed of satellite A.

____ (2)

(d) Calculate the magnitude of acceleration due to gravity at the altitude of satellite B.

____ (2)

10.

(a) Using the relationships $v = \sqrt{\frac{GM}{r}}$ and $v = \frac{2\pi r}{T}$, show that the radius of a satellite orbiting the Earth can be given by the equation $r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$, where M is the mass of the Earth, T is the period of the satellite, and r is the radius of the orbit.

(3)

(b) State two differences between geostationary orbits and polar orbits.

(2)

(c) Explain the advantage of launching a low-altitude equatorial-orbit satellite in a west-to-east direction.

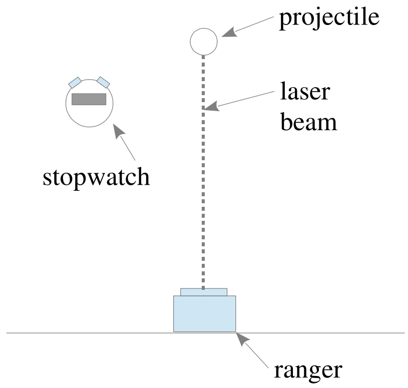
(2)

(d) Explain why the centre of the circular orbit of any Earth satellite must coincide with the centre of the Earth.

(3)

11. A student performs an experiment to determine the magnitude of acceleration due to gravity, *g*, using a stopwatch and a laser ranger, which measures distance by shining a laser beam onto the projectile. The procedure is shown below:

1. Place a laser ranger with its laser pointing upwards.
   The laser ranger will give the height of the projectile.
2. Hold the projectile at 50 cm directly above the ranger.
3. Drop the projectile and start the stopwatch. Stop the stopwatch when the projectile lands.
4. Reset the stopwatch and repeat steps 2 and 3 for 40, 30, 20 and 10 cm.



The results of the experiment are shown below:

Height (m)	**Square root of height ($\sqrt{m}$)**	**Time (s)**
0.50		0.45
0.40		0.38
0.30		0.36
0.20		0.28
0.10		0.21

(a) Complete the table above by calculating the values for Square root of height. (2)

(b) Plot a graph of the Time against Square root of height, and draw a line of best fit. (4)

(c) Calculate the gradient of the line of best fit.

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____ (3)

(d) Write an equation for the line of best fit.

____ (1)

(e) Use the slope of the line of best fit to calculate the acceleration of the projectile.

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(f) Evaluate the procedure by suggesting and explaining two improvements

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