

Assignment 3: total 30 marks

Show all working clearly and include diagrams where appropriate. Express all answers to the correct number of significant figures and units.

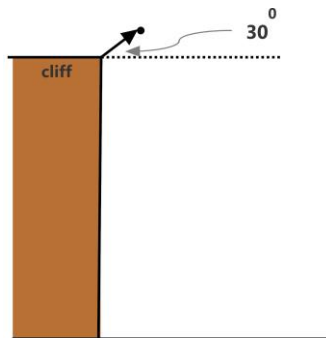
1. Calculate the gravitational force between the earth (mass = 6×10^{24} kg) and the sun (mass = 2×10^{30} kg) given that they are 150 000 000 km apart. Use $G = 6.67 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$.

(1 marks)

2. In a game of bowls, a bowl (1.5 kg) hits a stationary jack (300 g). After the collision the jack moves off at 2.5 m/s and the bowl at 0.6 m/s. Find the speed of the bowl just before it strikes the jack. Assume that the direction the bowl travels before the collision is the same as the direction the bowl and jack both travel after the collision.

(2 marks)

3. A stone was projected from the top of a 50 m high cliff, with an initial velocity of 20 m/s at an angle of 30° to the horizontal as shown.



Assuming no air resistance, calculate the following:

- a. The initial velocity of the stone in the vertical direction.
- b. The time taken for the stone to reach the top of its flight path.
- c. Distance the stone has to fall from the top of the flight path to the ground.
- d. Time taken for the stone to travel from the top of the flight path till it hits the ground.
- e. The horizontal component of the initial velocity.
- f. Horizontal distance from the cliff to where the stone landed.

(6 marks)

4. The driver of a 3.5 tonne truck takes his foot off the accelerator and coasts to a stop. If the truck was originally travelling at 26.0 m/s and it takes 250 m to stop.
- What was the truck's deceleration?
 - What was the frictional force causing the deceleration?
 - What is the coefficient of friction of the road with the wheels?

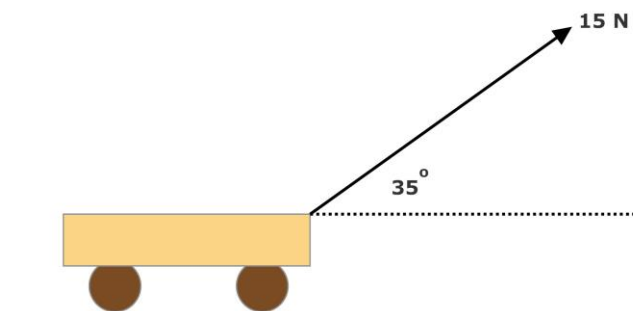
(3 marks)

5. A hammer swung in a 1.5 m radius circle makes 0.60 revolutions per second. If the mass of the hammer is 7.3 kg:

- How long does the hammer take to make one revolution?
- What is the hammer's linear velocity?
- What is the centripetal acceleration of the hammer?

(3 marks)

6. How much work is done if a wheeled toy is pulled 12 m along the ground with a rope as shown in the diagram?

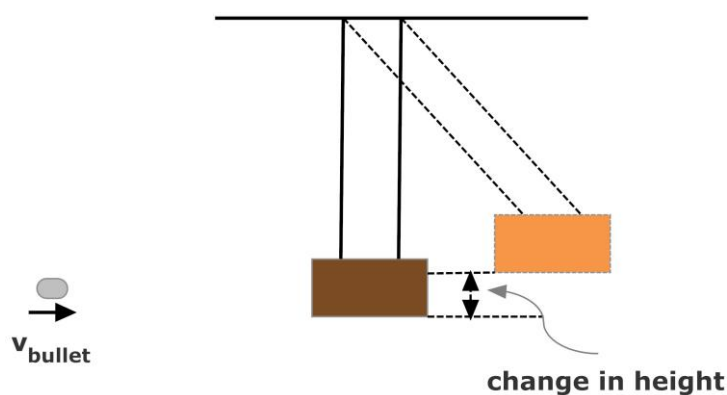


(2 marks)

- 7.
- Determine the amount of work done by the track motor in raising a 5000 kg roller-coaster 60 m.
 - If the motor has a power of 15 kW, how long will the 60 m lift take?

(4 marks)

8. A ballistic pendulum can be used to measure the speed of bullets. A bullet (mass of 5.0 g) is fired into a block of wood (mass of 4.995 kg) hanging from two cords. The block with the embedded bullet swings up to a maximum vertical height of 7 cm.



Assuming that the kinetic energy of the block at the bottom of the swing is converted to gravitational energy at the top of the swing, calculate:

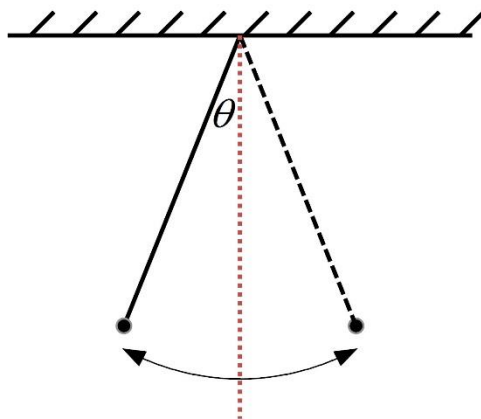
- The potential energy at the top of the swing.
- The velocity of the block plus bullet at the bottom of the swing.
- The momentum of the block plus bullet at the bottom of the swing.
- Given that momentum is conserved in the collision of the bullet with the block, calculate the velocity of the bullet just before it strikes the block.

(4 marks)

9. Pendulum experiment

The relationship between the period (T), the time for one swing over and back to its original position, and the length (L) of a pendulum is given by the formula:

$$T = 2\pi\sqrt{\frac{L}{g}} \quad \text{where } g \text{ is the acceleration due to gravity on earth.}$$



The following experiment can be used to calculate a value for g , the acceleration due to gravity.

A pendulum experiment was carried out on earth. A mass, suspended on a string, was held to a set position on one side and then allowed to swing. The time for 10 oscillations was measured and the period for one oscillation calculated. The experiment was repeated for the same mass, the same starting position (θ) but with varying pendulum lengths. Data collected for the pendulum length and the period for one oscillation is shown in the table below.

Table: Pendulum data: Length vs period.

Length L (m)	Period T (s)	Square of Period T^2
0.05	0.46	
0.10	0.63	
0.15	0.78	
0.20	0.93	
0.25	1.01	
0.30	1.10	
0.35	1.19	
0.40	1.27	
0.45	1.35	
0.50	1.42	
0.55	1.49	
0.60	1.55	
0.65	1.66	
0.70	1.68	
0.75	1.72	

- Complete the table to give values for T^2 (Square of the period).
- Rewrite the equation $T = 2\pi \sqrt{\frac{L}{g}}$ to make T^2 the subject. (Hint: The equation $y = \sqrt{x}$ can be rewritten as $y^2 = x$.)
- Plot T^2 (square of the period) against L (length of the pendulum). Ensure that the independent variable (L) is on the horizontal axis.
- Draw a straight line of best fit.
- Using the gradient of the line of best fit, calculate a value for g .- the acceleration due to gravity on earth. (Hint: Refer back to Module 1: Section 1.4.5).

(5 marks)

CHECK

- Did you work in the appropriate units?
- Did you include units in your answer?
- If the answer was a vector quantity, did you give the direction in which it acts?
- Did you answer each question in a sentence?