3 - Our Dynamic Universe Revision

1. A group of ramblers walk 8km due south followed by 12km on a bearing of 240° in 5 hours.

a) **By drawing a scale diagram**, find the displacement of the ramblers. **(3)**

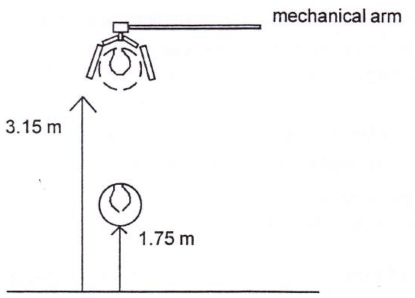
b) Calculate the average velocity of the ramblers. **(3)**

c) Another group of ramblers then leave a half hour later than the first group. They walk directly from the starting point to the finishing point of the first groups walk with the same average speed of the first group.

Show by calculation which group of ramblers get to the finishing point first, **group 1 or group 2?** **(4)**

2. The manufacturers of tennis balls require that the balls meet an industry standard. When dropped from a certain height onto a test surface, the balls must rebound to within a limited range of heights.

The ideal ball is one which, when dropped from rest from a height of 3.15m rebounds to a height of 1.75m, as shown below.



(a) **Assuming air resistance is negligible**, calculate or find:

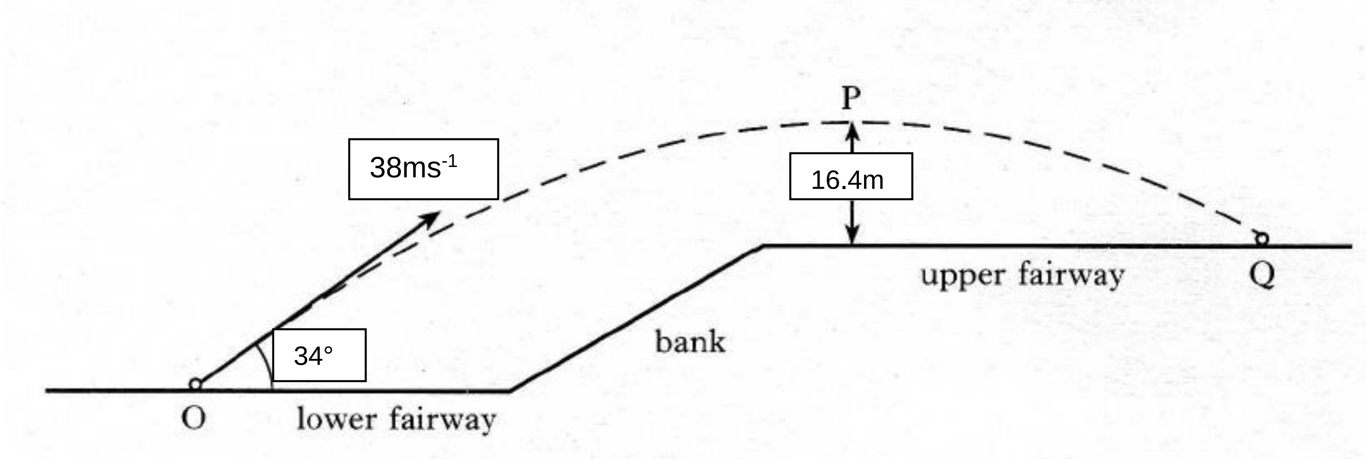
(i) The speed of an ideal ball just before contact with the ground. **(3)**

(ii) The speed of this ball just after contact with the ground. **(2)**

(b) When a ball is tested six times, the rebound heights are measured to be **1.71m, 1.78m, 1.72m, 1.76m, 1.73m, 1.74m**.

Calculate
(i) The mean value of the height of the bounce. **(1)**
(ii) The random uncertainty in this value. **(2)**

3. The fairway on a golf course is in two horizontal parts separated by a steep bank as shown below.



A golf ball at point O is given an initial velocity of 38 m s^{-1} at 34° to the horizontal.
The ball reaches a maximum vertical height at point P above the upper fairway.
Point P is 16.4 m above the fairway as shown.
The ball then hits the ground at point Q on the upper fairway as shown.

a) Show that the time taken for the ball to travel from **O** to **Q** is 4s. **(5)**

b) Calculate the **horizontal distance** travelled by the ball. **(4)**

c) i) How would the horizontal distance travelled by the ball calculated above compare with the value measured in practice? **(1)**

ii) What would this difference be due to? **(1)**

4. A person of mass 66kg enters the lift in a high storey flat to visit a relative. While ascending, the lift which is initially at rest then goes through the following stages before reaching the 20^{th} floor:

- Constant Accelerating upwards at $0.8ms^{-2}$
- Constant upward velocity of $5ms^{-1}$
- Constant Acceleration upwards at $-0.6ms^{-2}$
- Stationary at the 20th floor

Calculate or find:

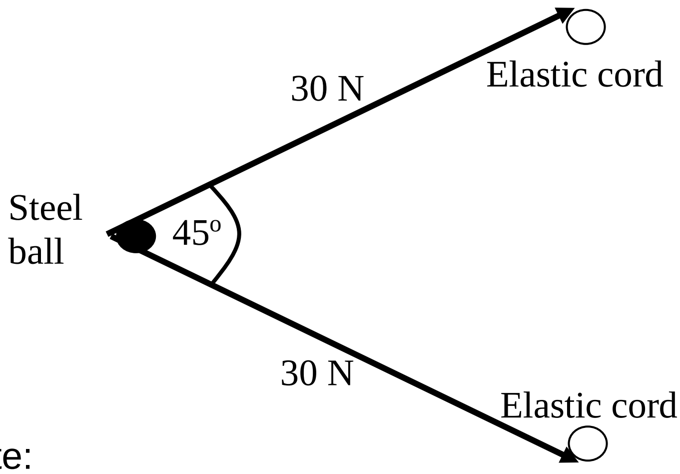
a) The reaction force of the floor on the person while stationary on the ground floor. **(3)**

b) The reaction force of the floor on the person while accelerating upwards at $0.8ms^{-2}$. **(3)**

c) The reaction force of the floor on the person while travelling with a constant velocity upwards of $5ms^{-1}$. **(1)**

d) The reaction force of the floor on the person while accelerating upwards at $-0.6ms^{-2}$. **(3)**

5. The diagram below represents a catapult about to launch a small steel ball of mass 0.1kg horizontally.
The air resistance acting against the steel ball in motion is 4.4N.



Calculate:

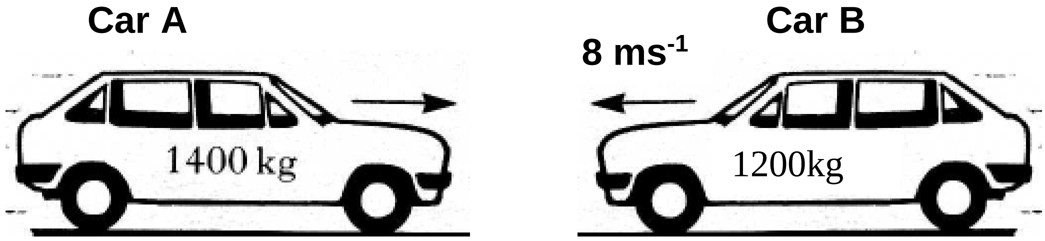
a) The **resultant force acting on the steel ball.** **(4)**

b) The **initial acceleration** of the steel ball in the horizontal direction **(3)**

c) **Give a reason** for this acceleration not remaining constant. **(1)**

6. a) **State the Law of Conservation of Linear Momentum** as it applies between two objects. **(1)**

Two cars, travelling in opposite directions, skid on a patch of smooth, level ice.
The two cars become entangled after the impact and continue to move in a straight line.



Immediately before the impact, car B is moving with a speed of **8ms^{-1}**.

Immediately after the impact, both cars are moving with a speed of **15ms^{-1} to the right**.

b) Calculate the **speed of car A** just before the collision takes place. **(3)**

c) **Show by calculation** what type of collision is taking place between the cars. **(3)**

7. A footballer has a ball of mass 450g passed to him by a team mate at 6ms^{-1}. He then passes the ball back directly to his team mate at 8ms^{-1}.

a) Calculate the average force exerted on the ball if the time of contact with the players foot is 40x10^{-3}s. **(3)**

b) Sketch a graph of the average force exerted by the player's foot against the time of contact with the ball. **(1)**

8. a) State **Newton's Law of Gravitation**. **(1)**

b) The weight of an object of mass 'm' in a gravity field is given by **W = mg.**

Using Newton's Law of Gravitation establish the equation.

$$g = \frac{GM}{R^2}$$

(2)

c) Calculate the **gravitational field strength** on the surface of an exoplanet of mass 8 x 10^{25}kg and radius 9200km. **(2)**

d) Calculate the average density of the planet. Given that

Density = Mass/Volume **(3)**

(Volume of a Sphere = 4/3 x πr^3)

9. Alpha Centauri, a nearby star in our galaxy, is at a distance of 4.3 light-years from Earth.

A rocket leaves from Earth for Alpha Centauri at a speed of 0.95c relative to an observer on Earth.

Assume that the Earth and Alpha Centauri are stationary with respect to one another.

a) Explain what is meant by the term **'time dilation'**? **(2)**

b) Calculate the **time** the Astronauts measure for their journey. **(3)**

c) Show by calculation **the distance** the astronauts would measure for this journey. **(3)**

10. a) **Explain** what is meant by the term '**length contraction**'. **(2)**

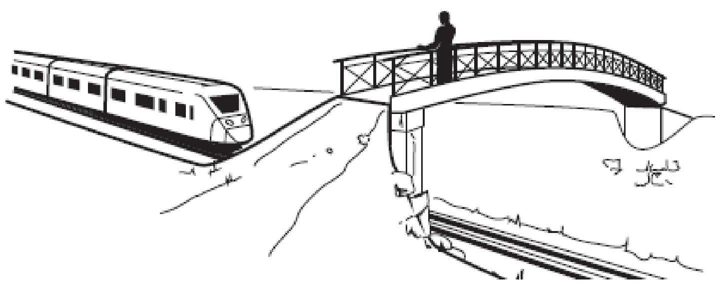
b) A rocket of length **65m** was measured at rest on Earth. The rocket passes Earth with a constant speed of **$2.3 \times 10^8 ms^{-1}$**.

Calculate the length of the rocket when it passes Earth and is measured by an observer that is stationary on Earth. **(3)**

11. A train is travelling at a constant speed of 16 m s^{-1} as it approaches a bridge. The driver sounds the horn which emits a sound of 277 Hz. The sound of the horn is heard by an observed on the bridge.

a) Explain how the **'Doppler Effect'** is applied to sound waves. **(2)**

b) Calculate the **frequency** of the sound heard by the person on the bridge. **(3)**



12. An astronomer observes the spectrum of light from a star.
The spectrum contains emission lines for hydrogen.

The astronomer compares this spectrum with the spectrum from a hydrogen lamp. The line which has a wavelength of 656nm from the lamp is found to be shifted to 663nm in the spectrum from the star.

a) Calculate the **redshift ratio** from this star. **(3)**

b) Calculate the **recessional velocity** of the star. **(3)**

13. A table of results is shown below of the recessional velocity of a galaxy against the distance to a galaxy.

Recessional Velocity ($x10^3$ ms^{-1})	**Distance ($x10^{22}m$)**
36	1.6
84	3.1
92	3.7
124	5.1
144	5.4

a) Draw a best fit straight line graph of recessional velocity against distance. **(3)**

b) Based on the graph, calculate the best estimate of Hubble's constant. **(3)**

c) Why has Hubble's constant changed a little over the years? **(1)**

14. Explain how the orbital speed of stars is evidence for **Dark Matter**.
A graph may be very useful to help with the explanation. **(3)**

Total Marks = 100