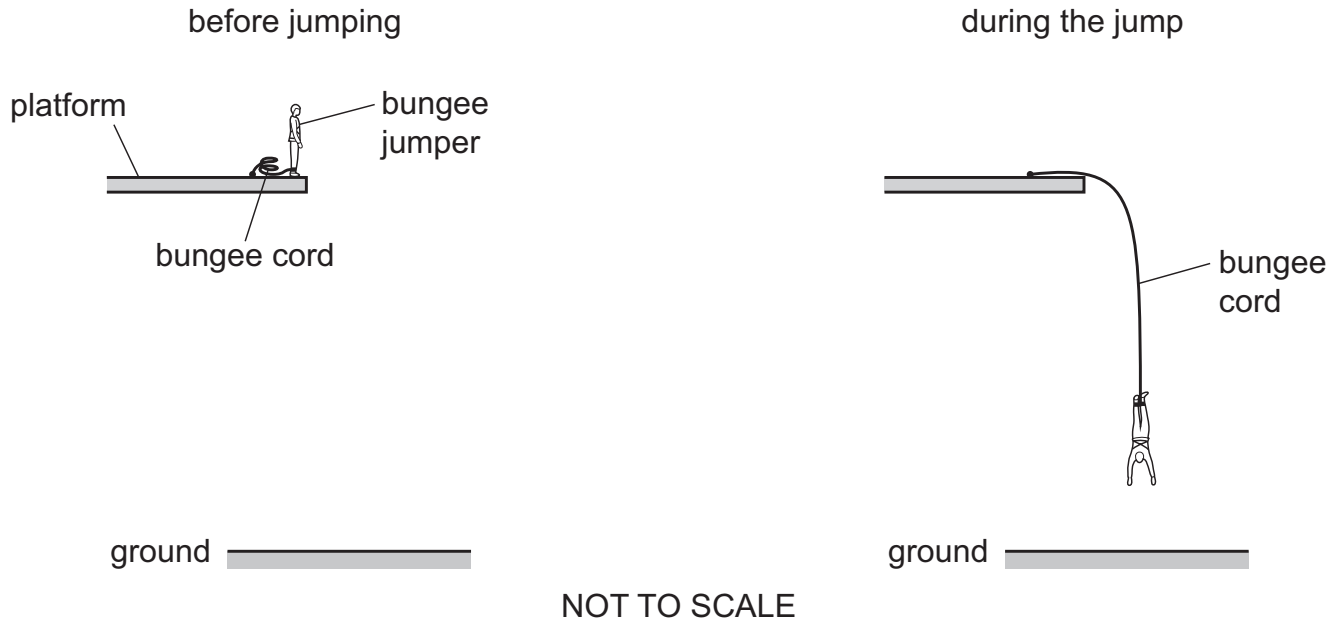
17 An object with a mass of 100 g falls a vertical distance of 10 m.

What is the change in the gravitational potential energy of the object?

A 1 J **B** 10 J **C** 100 J **D** 10 000 J

18 A bungee jumper jumps from a platform and is decelerated by an elastic bungee cord, as shown.



NOT TO SCALE

When the jumper makes the jump, his initial gravitational potential energy relative to the ground is converted into his kinetic energy and into elastic potential energy in the cord.

At which part of the jump are all three types of energy non-zero?

A on the platform before the jump

B on the way down before the cord has started to extend

C on the way down as he decelerates

D at the bottom of the jump when he is stationary

19 A sailboat is pushed by the wind at a constant velocity *v* across a lake.

The force of the wind and the velocity of the sailboat are in the same direction.

Which additional information is required to determine the work done per unit time by the wind acting on the sailboat?

A the force exerted by the wind

B the distance travelled by the sailboat per unit time

C the total energy input to the sailboat by the wind

D the weight of the sailboat

1 **(a)** Define acceleration.

.....

..... [1]

(b) A rocket is launched vertically from the surface of the Earth.

Fig. 1.1 shows the variation of the velocity of the rocket with time for the first 20 s after its launch.

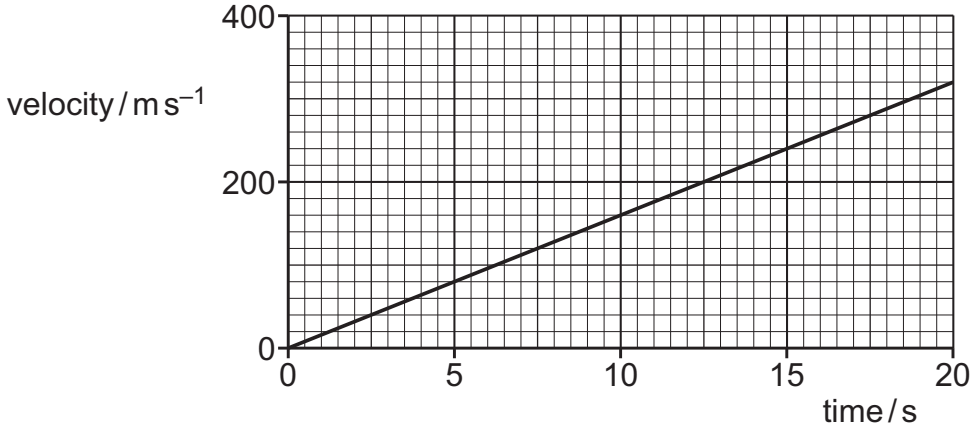


Fig. 1.1

(i) Determine the acceleration of the rocket.

acceleration = ... $m\,s^{-2}$ [1]

(ii) Show that the height of the rocket above the surface of the Earth at a time of 20 s after launch is 3.2 km.

[2]

(c) The mass of the rocket in **(b)** is 2.9×10^6 kg. Assume that this mass remains constant.

For this rocket, from launch to its height at a time of 20 s after launch:

(i) calculate the gain in gravitational potential energy ΔE_P

ΔE_P = ... J [2]

(ii) calculate the gain in kinetic energy ΔE_K

ΔE_K = ... J [2]

(iii) determine the average power output of the rocket engines. Assume that resistive forces are negligible.

power = ... W [2]

[Total: 10]

6 **(a)** State what is meant by a fundamental particle.

.....

..... [1]

(b) **(i)** Particle Q is a meson with a charge of 0.

Determine a possible quark composition for Q.

..... [2]

(ii) Particle Q has a mass of 0.67 u and a kinetic energy of 2.1×10^{-16} J.

Calculate the speed of particle Q.

speed = ... $m\,s^{-1}$ [3]

(c) Radium-228 ($^{228}_{88}Ra$) is a radioactive nuclide.

(i) State the number of electrons in a neutral atom of radium-228.

number of electrons = ... [1]

(ii) A nucleus of radium-228 undergoes a series of decays to form nucleus X.
During the process, 5 α-particles and 4 β^- particles are emitted.

Determine the number of protons and the number of neutrons in nucleus X.

number of protons = ...

number of neutrons = ...

[2]

[Total: 9]

1 On a bench, a steel ball of radius *r* is used to compress a spring by a distance *x*. The ball is held at rest in this position, as shown in Fig. 1.1.

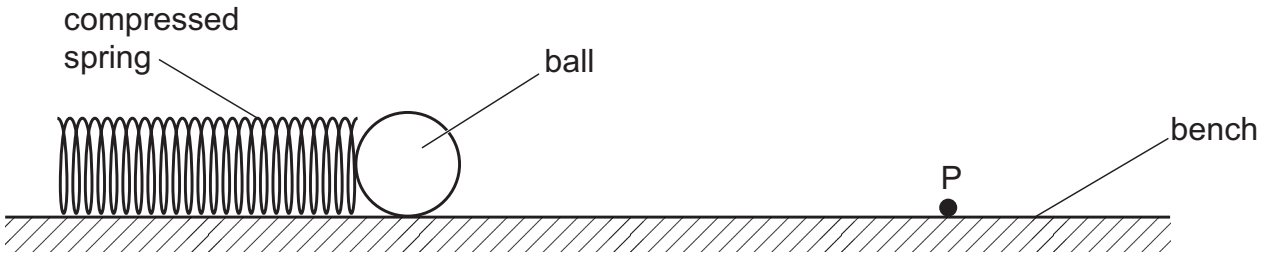


Fig. 1.1

The ball is released and rolls along the bench. At a fixed point P, the ball has speed *v*. The speed of the ball at P is determined using **one** light gate connected to a timer.

Several steel balls of different radii are available.

It is suggested that *v* is related to *r* by the relationship

$$v^2 = \frac{Ykx^2}{r^n\rho}$$

where *k* is the spring constant of the spring, ρ is the density of the steel, and *Y* and *n* are constants.

Plan a laboratory experiment to test the relationship between *v* and *r*.

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for *Y* and *n*.

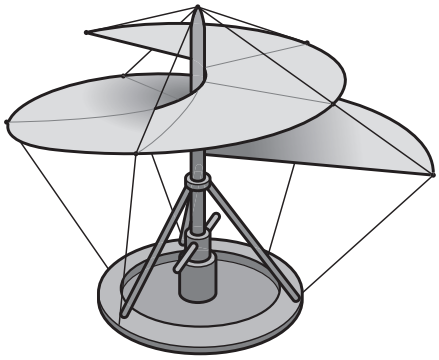
In your plan you should include:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

[15]

12 Leonardo da Vinci proposed a flying machine that would work like a screw to lift the pilot into the air. The 'screw' is rotated by the pilot.

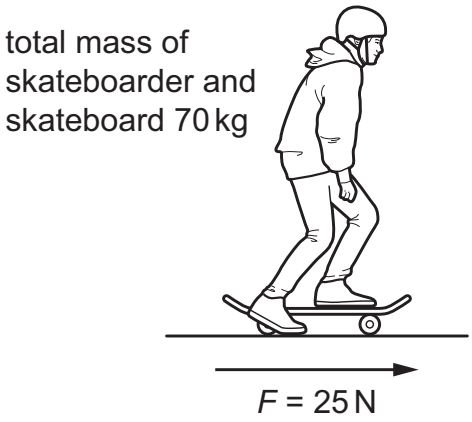


The machine and the pilot together have a total mass of 120 kg.

Which useful output power must the pilot provide to move vertically upwards at a constant speed of 2.5 m s^{-1}?

A 48 W **B** 300 W **C** 470 W **D** 2900 W

16 A skateboarder and her skateboard have a total mass of 70 kg. She pushes on the ground with her foot to create a forward force *F* of 25 N on herself and the skateboard, as shown in the diagram.



The skateboarder and skateboard travel forwards a distance of 0.50 m before the skateboarder lifts her foot from the ground.

What is the work done by *F* on the skateboarder and skateboard?

A 13 J **B** 50 J **C** 340 J **D** 360 J