

10 The Shanghai Maglev Train is the first commercially operated high-speed magnetic levitation train in the world, connecting the airport and central Shanghai.



(a) The total distance travelled is 29.9 km and the total journey time is 440 s. The train starts from rest and reaches a speed of 97 m s^{-1} in 120 s.

(i) Calculate the average acceleration of the train during the first 120 s.

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Average acceleration of train =

(ii) Calculate the average speed of the train for the period following the 120 s acceleration.

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Average speed of train =

(b) Electromagnetic forces enable the train to levitate above a steel rail.

Explain why magnetic levitation is an advantage for a high-speed transport system.

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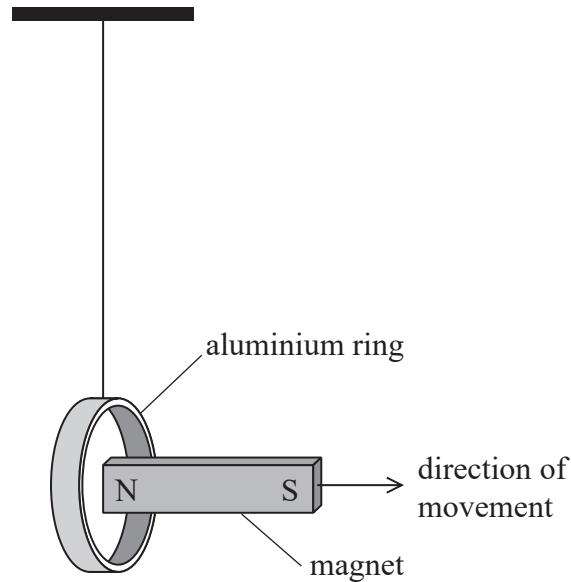
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- * (c) A linear induction motor provides the force to accelerate the train forwards. A current flows in sequence through coils of wire mounted in the track. The train is dragged along as the magnetic field progresses along the coils of wire in the track. This is similar to moving a permanent magnetic field away from a conductor.

A teacher demonstrates this effect by quickly removing one end of a bar magnet from a suspended aluminium ring.



When the magnet is removed from the ring, the ring moves in the same direction as the magnet.

Explain, using the laws of electromagnetic induction, why the ring moves in the direction of the magnet.

(6)

(Total for Question 10 = 13 marks)



- 8 In the sport of curling, two teams of ‘curlers’ take turns sliding polished granite stones across an ice surface towards a circular target marked on the ice.



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- (a) A stone of mass 19.6 kg is accelerated uniformly for 1.25 s before being released by a curler. The stone then decelerates uniformly to rest, travelling 32.5 m in a time of 17.5 s .

Calculate the average useful power developed by the curler in accelerating the stone.

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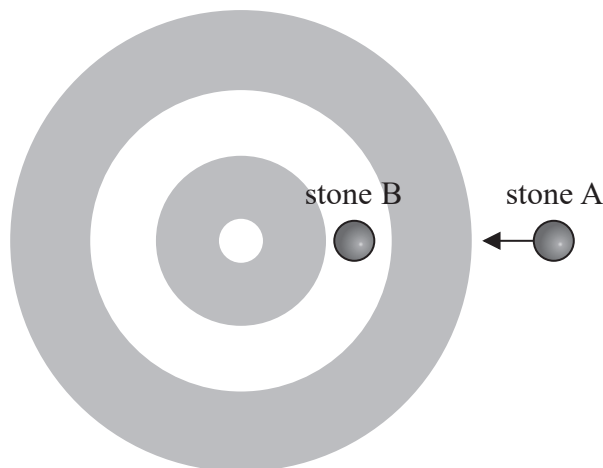
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Average power =

- *(b) Stone B is stationary. Stone A travels towards the target and makes a direct hit on stone B as shown. Both stones have mass m .



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The collision is elastic. Just before the collision stone A has a velocity v . After the collision stone B moves off with velocity v .

Discuss how the relevant conservation laws apply to this collision.

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(c) While a stone is moving towards the target, the curlers vigorously sweep the ice directly in front of the stone.

Explain why this may make the stone travel further.

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(Total for Question 8 = 12 marks)

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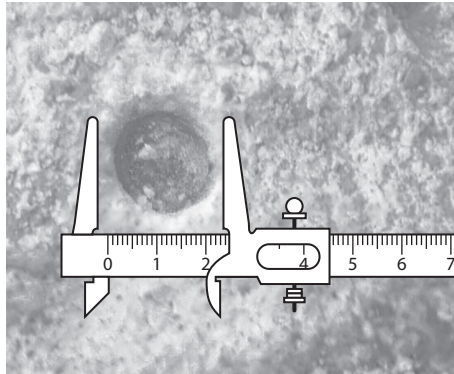
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- 12 Impact craters are formed when meteorites strike the surface of a planet. A student investigated some factors that might influence the formation of impact craters. He did this by dropping spheres of modelling clay into a tray of sand.

The diameter of the crater produced by each sphere was measured using vernier calipers as shown.



This process was repeated for spheres of different diameters.

- (a) In one test, the spheres were dropped from the same height.

Determine the factor by which the kinetic energy of the sphere just before impact increases when the sphere diameter is increased from 2.0 cm to 4.0 cm.

(3)

Factor =

- *(b) The student also dropped the spheres from different heights. His results are shown in the table.

Drop height / m	Sphere diameter / cm	Crater diameter / cm
0.30	2.0	3.6
	4.0	7.0
	6.0	6.8
0.60	2.0	4.8
	4.0	7.5
	6.0	7.3
0.90	2.0	5.6
	4.0	8.0
	6.0	8.3



11 Solar panels consisting of combinations of photovoltaic cells use energy in the radiation received from the Sun to generate electricity.

- (a) An advertisement for solar panels claims that the intensity of radiation from the Sun incident at the top of the Earth's atmosphere is more than 2 kW m^{-2} .

Assess the validity of this claim.

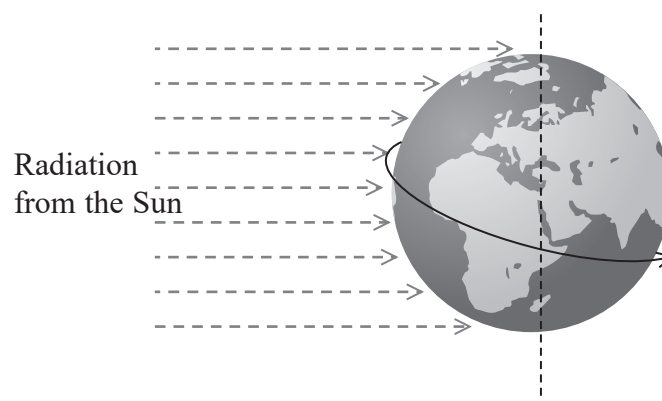
radius of Sun = $6.96 \times 10^8 \text{ m}$

surface temperature of Sun = 5790 K

distance from Sun to Earth = $1.50 \times 10^{11} \text{ m}$

(4)

- (b) The average intensity of radiation from the Sun incident at the Earth's surface over a 24-hour period has been determined to be 164 W m^{-2} .



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- (i) The average intensity of radiation from the Sun at the Earth's surface is much less than the intensity incident at the top of the Earth's atmosphere.

Explain why.

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- (ii) It is claimed that the area of solar panels needed to generate 100 GW of power is about 0.5% of the surface area of the Earth.

Assess the validity of this claim.

radius of Earth = 6.4×10^6 m

typical efficiency of solar panels = 25%

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(c) Scientists are developing a space station equipped with large solar panels. The space station would be located in a geostationary orbit. The space station would transfer energy to Earth as microwaves.

(i) A space station in a geostationary orbit is above the equator and has a period of 24 hours.

Explain one advantage of locating the space station in a geostationary orbit.

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(ii) Calculate the height h of the space station above the equator when it is in a geostationary orbit.

mass of Earth = 6.00×10^{24} kg

24 hours = 8.64×10^4 s

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$h =$

(Total for Question 11 = 18 marks)

TOTAL FOR PAPER = 120 MARKS



(b) Explain how the principle of conservation of energy applies to this collision.

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(Total for Question 7 = 8 marks)

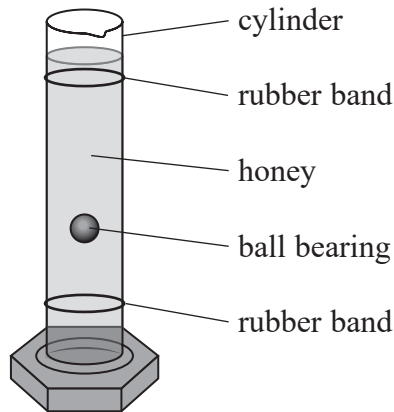
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- 10 A student carried out an experiment to determine the viscosity of some honey. He filled a tall glass cylinder with honey as shown, and timed a ball bearing as it fell through the honey.



- (a) The student placed rubber bands near the top and bottom of the cylinder. He started a stopwatch when the ball bearing passed the first band and stopped the stopwatch when the ball bearing passed the second band. He repeated this several times to determine a mean time.

Criticise the student's method.

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- (b) The time t for the sphere to fall through a distance of 25.0 cm is shown in the table.

t/s			
6.40	6.35	6.36	6.38

- (i) Show that the mean velocity v of the ball bearing is about 0.04 m s^{-1} .

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- (ii) The student had three different types of honey available.

Viscosity η is given by the following expression

$$\eta = \frac{2r^2g(\rho_B - \rho_H)}{9v}$$

radius r of ball bearing = 5.50×10^{-3} m

density of ball bearing $\rho_B = 7750 \text{ kg m}^{-3}$

density of honey $\rho_H = 1360 \text{ kg m}^{-3}$

Viscosity (at 20°C)/Pa s		
Honey A	Honey B	Honey C
10.6	12.5	13.6

Deduce which honey the student used.

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(Total for Question 10 = 7 marks)

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