

1

Which of the following is **not** a unit of power?

A N m s^{-1}

☐

B $\text{kg m}^2 \text{s}^{-3}$

☐

C J s^{-1}

☐

D $\text{kg m}^{-1} \text{s}^{-1}$

☐

(Total 1 mark)

2

A cyclist travelling along a level road at a constant speed of 15 m s^{-1} experiences a resistive force of 12 N due to air resistance.

(a) Calculate the power output of the cyclist maintaining this constant speed.

power output _____ W

(2)

(b) State and explain any change in the power output of the cyclist when cycling at a higher, constant speed.

(2)

(Total 4 marks)

3

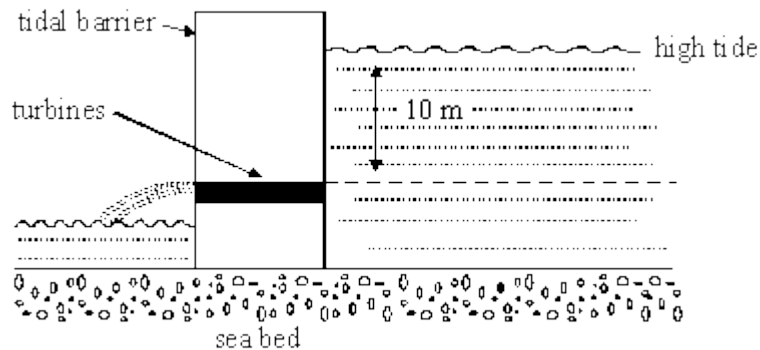
A weightlifter lifts a weight of 1500 N through a height of 0.35 m in a time of 0.85 s. Calculate the mean power developed by the weightlifter.

power _____ W

(Total 2 marks)

4

Tidal power could make a significant contribution to UK energy requirements. This question is about a tidal power station which traps sea water behind a tidal barrier at high tide and then releases the water through turbines 10.0 m below the high tide mark.



- (i) Calculate the mass of sea water covering an area of 120 km^2 and depth 10.0 m.

density of sea water = 1100 kg m^{-3}

- (ii) Calculate the maximum loss of potential energy of the sea water in part (i) when it is released through the turbines.

- (iii) The potential energy of the sea water released through the turbines, calculated in part (ii), is lost over a period of 6.0 hours. Estimate the average power output of the power station over this time period. Assume the power station efficiency is 40%.

(Total 7 marks)

5

A car accelerates at a steady rate of 2.5 m s^{-2} along a straight, level road. The mass of the car is $1.3 \times 10^3 \text{ kg}$.

- (a) Calculate the magnitude of the resultant force acting on the car.

(2)

- (b) When the accelerating car reaches a speed of 2.2 m s^{-1} , the total force opposing the motion of the car is 410 N.

Calculate

- (i) the driving force provided by the wheels,

- (ii) the power delivered to the wheels of the car.

(3)

- (c) Explain how the total force opposing the motion of the car is affected when it is travelling up a hill.

(1)

(Total 6 marks)

6

The diagram shows a car travelling at a constant velocity along a horizontal road.



- (a) (i) Draw and label arrows on the diagram representing the forces acting on the car.
- (ii) Referring to Newton's Laws of motion, explain why the car is travelling at constant velocity.

(5)

- (b) The car has an effective power output of 18 kW and is travelling at a constant velocity of 10 m s^{-1} . Show that the total resistive force acting is 1800 N.

(1)

- (c) The total resistive force consists of two components. One of these is a constant frictional force of 250 N and the other is the force of air resistance, which is proportional to the square of the car's speed.

Calculate

- (i) the force of air resistance when the car is travelling at 10 m s^{-1} ,

- (ii) the force of air resistance when the car is travelling at 20 m s^{-1} ,

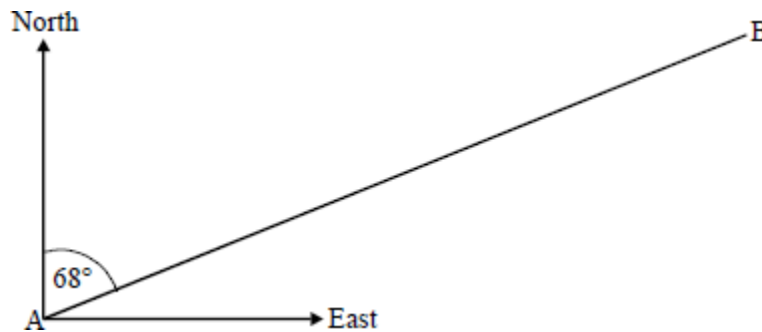
- (iii) the effective output power of the car required to maintain a constant speed of 20 m s^{-1} in a horizontal road.

(4)

(Total 10 marks)

7

A microlight is a small aircraft powered by a petrol engine. The diagram represents the flight path, AB, of a microlight on a short horizontal training flight.



- (a) On its outward journey, the wind velocity is 7.5 m s^{-1} due North and the resultant velocity of the microlight is 20 m s^{-1} in a direction 68° East of North, so that it travels along AB.
- (i) Show that for the aircraft to travel along AB at 20 m s^{-1} it should be pointed due East.

- (ii) The driving force of the aircraft engine is $2.0 \times 10^3 \text{ N}$. Calculate the work done by the engine if the aircraft travels 10 km on its outward journey.

(iii) Calculate the output power of the aircraft engine for the outward journey.

(6)

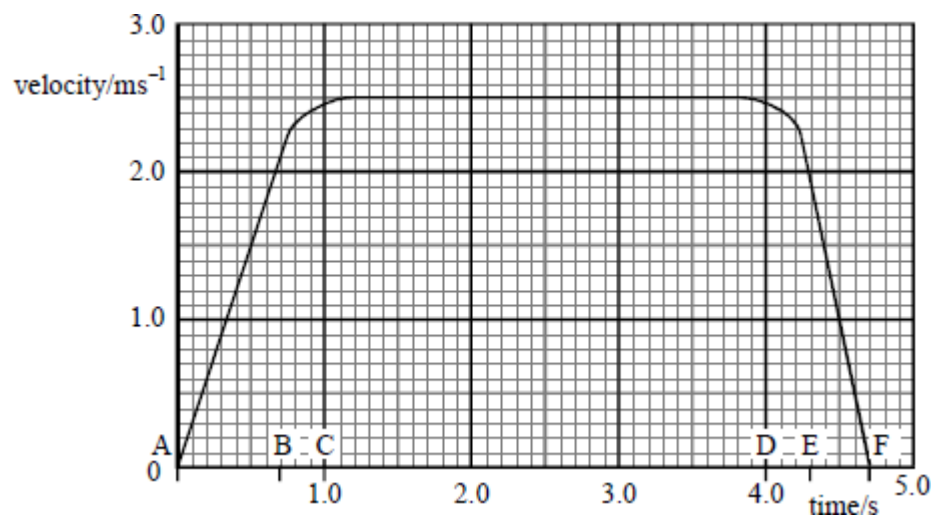
(b) After flying 10km, the aircraft turns round and returns along the same flight path at a resultant velocity of 14 m s^{-1} . Assuming that the turn-round time is negligible, calculate the average speed for the complete journey.

(2)

(Total 8 marks)

8

A mass of 1500 kg is attached to a cable and raised vertically by a crane. The graph shows how its velocity varies with time.



(a) Determine

(i) the initial uniform acceleration of the mass, _____

- (ii) the distance travelled by the mass while it is accelerating upwards.

(3)

- (b) (i) Calculate the tension in the cable in the intervals

AB, _____

CD _____

- (ii) State in which interval of the motion the tension in the cable is least.

(4)

- (c) Calculate the power supplied by the crane during the interval CD.

(2)

(Total 9 marks)

9

A car exerts a driving force of 500 N when travelling at a constant speed of 72 km h^{-1} on a level track. What is the work done in 5 minutes?

A $3.0 \times 10^6 \text{ J}$

☐

B $2.0 \times 10^6 \text{ J}$

☐

C $2.0 \times 10^5 \text{ J}$

☐

D $1.1 \times 10^5 \text{ J}$

☐

(Total 1 mark)

Mark schemes

D

[1]

(a) correct substitution into $P = Fv$

C1

180 (W)

A1

2

(b) higher power output/more air resistance

B1

refers to $P = Fv$ **and** states force (provided by cyclist) is greater while travelling at higher speed

B1

2

[4]

$$\text{work done} = 1500 \times 0.35 (525\text{J})$$

or power = work done/time taken **(1)**

C1

615-620W (1) 2 or 3 sf only

A1

[2]

(a) (i) area = $120 \times 10^6 \text{ (m}^2\text{)}$ **(1)**

$$\text{mass} = 120 \times 10^6 \times 10 \times 1100 = 1.3 \times 10^{12} \text{ kg} \quad (1)$$

(ii) (use of $E_p = mgh$ gives) $\Delta E_p = 1.3 \times 10^{12} \times 9.8 \times 5 = 6.4 \times 10^{13} \text{ J}$ **(1)**
(allow C.E. for incorrect value of mass from (i))

- (iii) power (from sea water) = $\frac{6.4 \times 10^{13}}{6 \times 3600}$
 [or correct use of $P = Fv$]
 = 3000 (MW) **(1)**
 (allow C.E. for incorrect value of ΔE_p from (ii))
 power output = 3000×0.4 **(1)**
 = 120 MW **(1)**
 (allow C.E. for incorrect value of power)

[7]

5

- (a) (use of $F = ma$ gives) $F = 1.3 \times 10^3 \times 2.5$ **(1)**
 = 3250 N **(1)** (3.25×10^3)

2

- (b) (i) driving force = $3250 + 410 = 3660$ N **(1)**
 (allow C.E. from (a))

- (ii) (use of $P = Fv$ gives) $P = 3660 \times 2.2$ **(1)**
 (allow C.E. from (i))
 = 8100 W **(1)** (8.1×10^3)

3

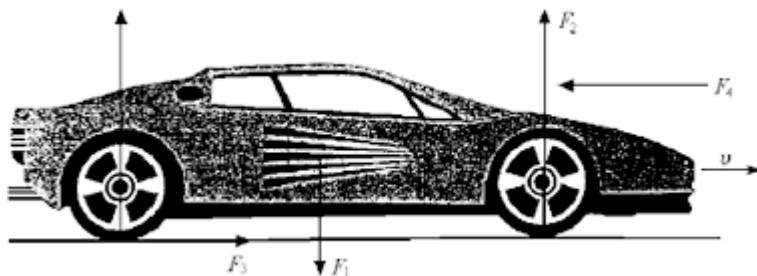
- (c) (component of) car's weight opposes motion
 [or overcomes gravity
 or more work is done as car gains potential energy] **(1)**

1

[6]

6

- (a) (i)



F_1 weight / mg **(1)**

F_2 reaction or normal contact force **(1)**

F_3 driving force **(1)**

F_4 friction or air resistance **(1)**

- (ii) zero acceleration **(1)**
 zero resultant force **(1)**

The Quality of Written Communication marks were awarded primarily for the quality of answers to this part.

(max 5)

(b) ($P = Fv$ gives) $18 \times 10^3 = F \times 10$ **(1)** (and $F = 1.8 \times 10^3$ N)

(1)

(c) (i) $1800 - 250 = 1.6 \times 10^3$ N **(1)** (1.55×10^3 N)

(ii) force = $4 \times 1.55 \times 10^3 = 6.2 \times 10^3$ N **(1)**
(allow e.c.f. from (i))

(iii) total force = $6200 + 250$ (N) **(1)** ($= 6.45 \times 10^3$ (N))
($P = Fv$ gives) $P = 6.45 \times 10^3 \times 20 = 1.3 \times 10^5$ W **(1)** (1.29×10^5 W)
(allow e.c.f. for value of total force)

(4)

[10]

7

(a) (i) component velocity North = $20 \cos 68^\circ$ **(1)**
 $= 7.5 \text{ m s}^{-1}$
which is supplied by wind **(1)**
by triangle of velocities [or by components] (aircraft must point East) **(1)**

alternative (a)(i)
triangle or parallelogram of velocities **(1)**
find angle between aircraft component and wind using sine and cosine formulae – prove 90° **(1) (1)**

(ii) work done = $F \cos \theta$ [or force $\times$ distance moved in direction of force
or $2.0 \times 10^3 \times 10 \times 10^3 \cos 22^\circ$] **(1)**
 $= 1.8(5) \times 10^7$ J **(1)**

(iii) power = $\frac{\text{work done}}{\text{time taken}} = 1.8(5) \times 10^7 \div \left(\frac{10000}{20}\right)$ **(1)**
 $= 3.6 \times 10^4$ W **(1)**

alternative (iii)
power = force $\times$ velocity component East = $2.0 \times 10^3 \times 20 \cos 22^\circ$ **(1)**
 $= 3.6 \times 10^4$ W **(1)**

(max 6)

(b) return time = $\left(\frac{10000}{14}\right) = 714$ s $\therefore$ total time = 1214 s **(1)**

average speed = $\left(\frac{20000}{1214}\right) = 16[16.5]$ m s $^{-1}$ **(1)**

(2)

[8]

8

(a) (i) $\text{gradient} = \frac{2.1}{0.7} = 3.0 \text{ ms}^{-2}$ **(1)**

(ii) distance is area under graph (to $t = 0.1 \text{ s}$)

$$\text{or } \frac{1}{2} \times 0.7 \times 2.1 \left(\frac{2.1 + 2.5}{2} \right) 0.3 \text{ (1)} = 1.4(2) \text{ m (1)}$$

3

(b) (i) $T - mg = ma$ [or $T = 1500(9.8 + 3.0)$] **(1)**
 $= 1.9 \times 10^4 \text{ N (1)}$

$$T = mg = 1.5 \times 10^4 \text{ N (1)}$$

(ii) EF **(1)**

4

(c) power = Fv or $1.5 \times 10^4 \times 2.5$ **(1)**
 $= 3.7[3.8] \times 10^4 \text{ W (1)}$

2

[9]**9**

A

[1]