Exercise 4D

1

$$\begin{aligned}\text{Power} &= Fv \\ &= 1500 \times 12 \\ &= 18\ 000\end{aligned}$$

The power is 18 kW

2

$$\begin{aligned}\text{Power} &= Fv \\ &= 1000 \times 15 \\ &= 15\ 000\end{aligned}$$

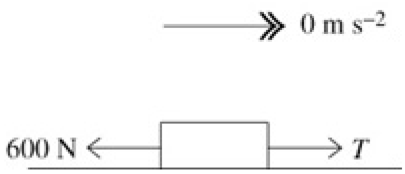
The power is 15 000 W (or 15 kW)

3

$$\text{Power} = Fv$$
$$5000 = F \times 18$$
$$\begin{aligned}F &= \frac{5000}{18} \\ &= 277.7\ldots\end{aligned}$$

The driving force has magnitude 278 N (3 s.f.)

4



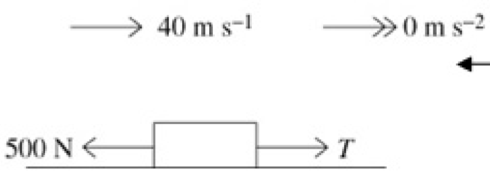
At maximum speed the acceleration is zero.

Resolving horizontally: $T = 600$

$$\text{Power} = Fv$$
$$15\,000 = 600v$$
$$\begin{aligned}v &= \frac{15\,000}{600} \\ &= 25\end{aligned}$$

The maximum speed is 25 m s^{-1}

5 a



At maximum speed the acceleration is zero.

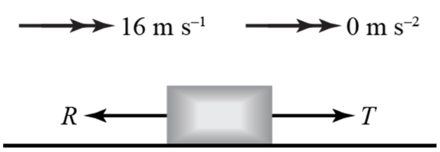
Resolving horizontally: $T = 500$

$$\begin{aligned}\text{Power} &= Fv \\ &= 500 \times 40 \\ &= 20\,000\end{aligned}$$

The power is 20 000 W (or 20 kW)

b The resistance to motion of the car would typically be expected to increase with speed but it would be reasonable to assume a constant resistive force if the car maintained the same speed and the gradient and surface of the road stayed the same.

6



Power $= Fv$

$8.8 \times 10^3 = T \times 16$

$T = \frac{8800}{16}$

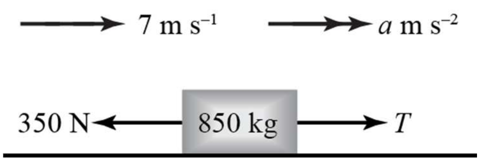
$T = 550$

Resolving horizontally: $R = T$

$R = 550$

The magnitude of the resistance is 550 N

7 a



Power $= Fv$

$9000 = T \times 7$

$T = \frac{9000}{7}$

First find the tractive force produced by the engine and then use $F = ma$ to find the acceleration.

Now using $F = ma$:

$T - 350 = ma$

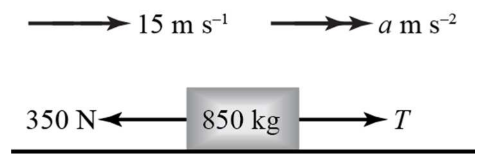
$\frac{9000}{7} - 350 = 850a$

$a = \frac{\frac{9000}{7} - 350}{850}$

$a = 1.100\ldots$

The acceleration is 1.10 m s^{-2} (3 s.f.)

7 b



Power $= Fv$

$$9000 = T \times 15$$

$$T = \frac{900}{15} = 600$$

Now using $F = ma$:

$$T - 350 = ma$$

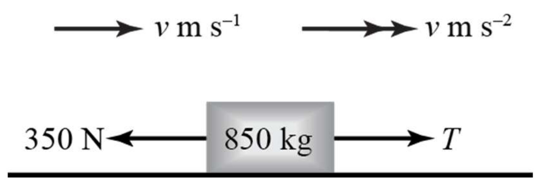
$$600 - 350 = 850a$$

$$a = \frac{250}{850}$$

$$a = 0.2941\ldots$$

The acceleration is 0.294 m s^{-2} (3 s.f.)

c



Resolving horizontally: $T = 350$

Power $= Fv$

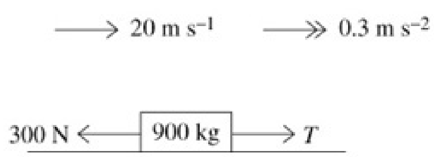
$$9000 = 350v$$

$$v = \frac{9000}{350}$$

$$v = 25.71\ldots$$

The maximum speed is 25.7 m s^{-1} (3 s.f.)

8



Using $F = ma$:

$$T - 300 = 900 \times 0.3$$

$$T = 900 \times 0.3 + 300$$

$$= 570$$

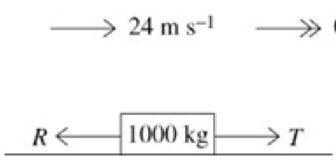
$$\text{Power} = Fv$$

$$= 570 \times 20$$

$$= 11\,400$$

The power development by the engine is 11 400 W (or 11.4 kW)

9



Power $= Fv$

$12\,000 = T \times 24$

$$T = \frac{12\,000}{24} = 500$$

Using $F = ma$:

$T - R = 1000 \times 0.2$

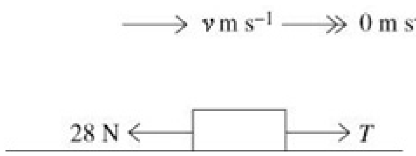
$500 - R = 200$

$R = 500 - 200$

$R = 300$

The value of R is 300.

10



Resolving horizontally:

$T = 28$

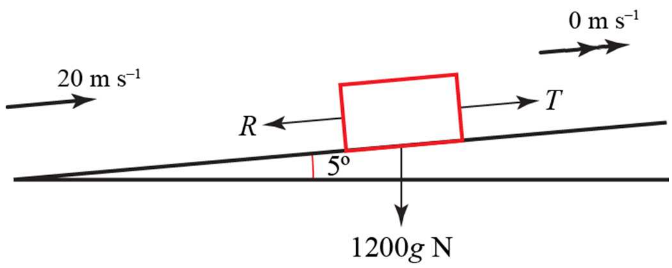
Power $= Fv$

$280 = 28v$

$v = 10$

The cyclist's maximum speed is 10 m s^{-1}

11 a



Power $= Fv$

$24\,000 = T \times 20$

$$T = \frac{24\,000}{20} = 1200$$

Resolving parallel to the slope:

$T = R + 1200g \sin 5°$

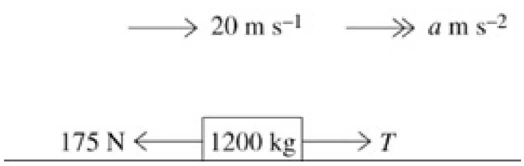
$1200 = R + 1200g \sin 5°$

$R = 1200 - 1200g \sin 5°$

$R = 175.04\ldots$

The value of R is 175 (3 s.f.)

11 b



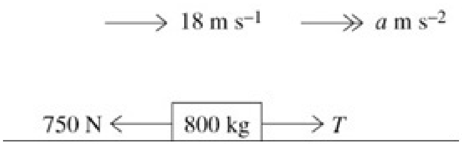
From part **a**, $T = 1200$ N
Using $F = ma$:
$1200 - 175 = 1200a$

$$a = \frac{1200 - 175}{1200}$$

$$a = 0.8541\ldots$$

The initial acceleration of the van is 0.854 m s^{-2} (3 s.f.)

12 a



Power $= Fv$
$26000 = T \times 18$

$$T = \frac{26000}{18}$$

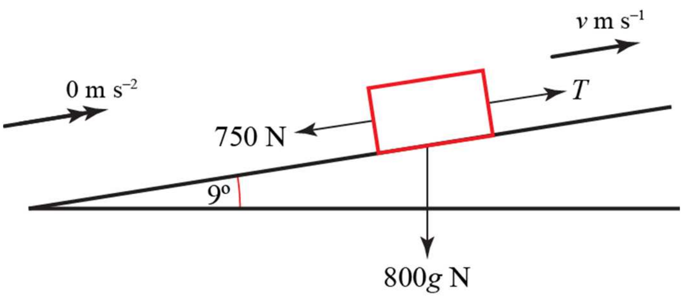
Using $F = ma$:
$T - 750 = 800a$

$$800a = \frac{26000}{18} - 750$$

$$a = 0.8680\ldots$$

The acceleration is 0.868 m s^{-2} (3 s.f.)

b



Resolving parallel to the slope:
$T = 750 + 800g\sin 9°$
Power $= Fv$
$26000 = T \times v$

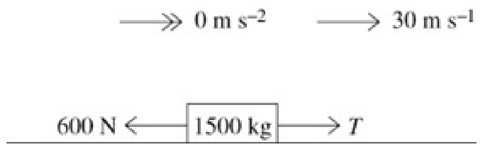
$$26000 = (750 + 800 \times 9.8\sin 9°)v$$

$$v = \frac{26000}{(750 + 800 \times 9.8\sin 9°)}$$

$$v = 13.15\ldots$$

The maximum speed is 13.2 m s^{-1} (3 s.f.)

13 a

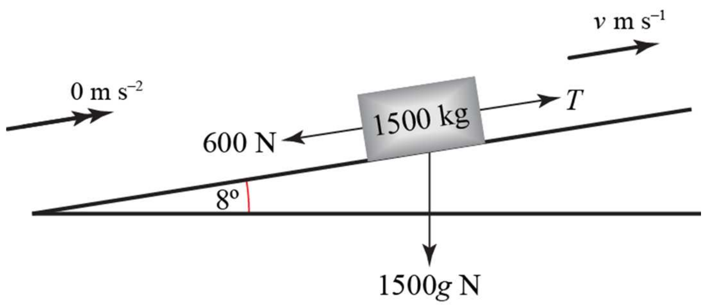


Resolving horizontally: $T = 600$

$$\begin{aligned}\text{Power} &= Fv \\ &= 600 \times 30 \\ &= 18000\end{aligned}$$

The power is 18 000 W (or 18 kW)

b



Resolving parallel to the slope:

$T = 600 + 1500g \sin 8°$

Power $= Fv$

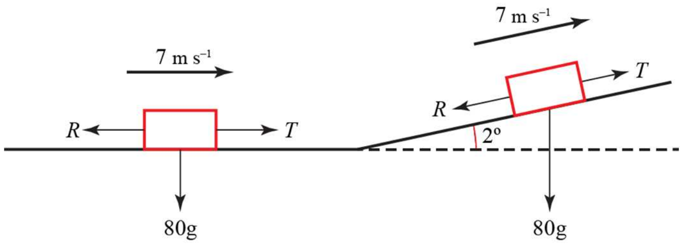
$$18000 = (600 + 1500g \sin 8°)v$$

$$v = \frac{18000}{(600 + 1500g \sin 8°)}$$

$$= 6.803\ldots$$

The maximum speed is 6.80 m s^{-1} (3 s.f.)

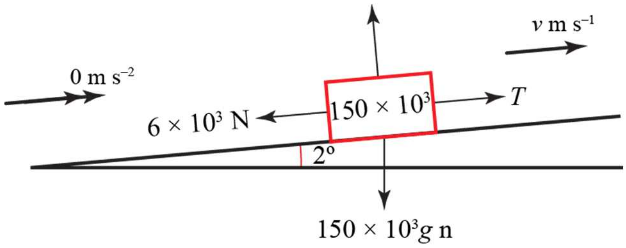
14



Consider the cyclist on level ground:
Power $= Tv$
Power $= 7T$
Since the velocity is constant, resolving horizontally:
$T = R$
So power $= 7R$

Consider the cyclist cycling uphill:
Power $= Tv$
Power $= 7T$
Since the velocity is constant, resolving parallel to the plane:
$T = R + 80g\sin 2°$
So power $= 7T = 7(R + 80g\sin 2°) = 7R + 560g\sin 2°$
Therefore, the increase in power required is:
$(7R + 560g\sin 2°) - 7R = 560g\sin 2°$
$= 191.5\ldots$
The increase in power required is 192 W (3 s.f.)

15 a



Resolving parallel to the slope:
$T = (6\times10^3) + (150\times10^3 g\sin2°)$
Power $= Fv$

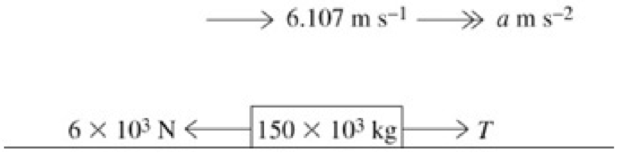
$350\times10^3 = (6\times10^3 + 150\times10^3 g\sin2°)\times v$

$$v = \frac{350}{(6+150\times9.8\sin2°)}$$
$$= 6.107\ldots$$

The maximum speed is 6.11 m s^{-1}

1 tonne = 10^3 kg. When tonnes, kilonewtons and kilowatts are used the 10^3 will cancel, leaving easier numbers.

b

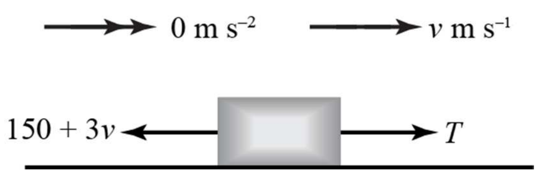


Power $= Fv$
$350\times10^3 = T\times6.107$
$$T = \frac{350\times10^3}{6.107}$$

Using $F = ma$:
$$T - 6\times10^3 = 150\times10^3\times a$$
$$\frac{350\times10^3}{6.107} - 6\times10^3 = 150\times10^3\times a$$
$$150a = \frac{350}{6.107} - 6$$
$$a = 0.3420\ldots$$

The initial acceleration is 0.342 m s^{-2} (3 s.f.)

16



Power $= 10\text{ kW} = 10\,000\text{ W}$

Power $= Tv$

$10\,000 = Tv$

$T = \dfrac{10\,000}{v}$

When the velocity is maximum, the acceleration = 0 m s^{-2}

Therefore the resultant force is 0 N. Resolving horizontally:

$T = 150 + 3v$

So $\dfrac{10\,000}{v} = 150 + 3v$

$10\,000 = 150v + 3v^2$

Rearranging:

$$3v^2 + 150v - 10\,000 = 0$$

Using the quadratic formula:

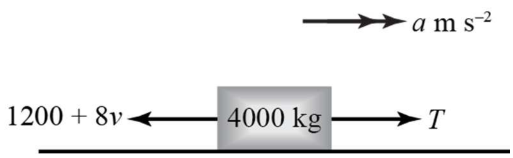
$$v = \frac{-150 \pm \sqrt{150^2 - 4 \times 3 \times (-10\,000)}}{6}$$

$$v = \frac{-150 \pm \sqrt{142\,500}}{6}$$

Since $v > 0$, $v = \dfrac{-150 + \sqrt{142\,500}}{6} = 37.91\ldots$

The maximum value of v is 37.9 m s^{-1} (3 s.f.)

17 a



Power = 28 kW = 28 000 W
Power $= Tv$
$28\,000 = Tv$

$$T = \frac{28\,000}{v}$$

Resolving horizontally and using $F = ma$:

$$\frac{28\,000}{v} - (1200 + 8v) = 4000a$$

When $v = 10$ m s^{-1}:

$$2800 - (1200 + 80) = 4000a$$
$$1520 = 4000a$$

So $a = \dfrac{1520}{4000} = 0.38$ m s^{-2}

b Using $P = Fv$, when the car is travelling at speed w:
$28\,000 = Tw$

$$T = \frac{28\,000}{w}$$

Resistive force = 1200 + 8w
As in part **a**, resolving horizontally and using $F = ma$:

$$\frac{28\,000}{w} - (1200 + 8w) = 4000a$$

When $v = w$ m s^{-1}, $a = -0.2$ m s^{-2}:

$$\frac{28\,000}{w} - (1200 + 8w) = 4000 \times (-0.2)$$
$$28\,000 - 1200w - 8w^2 = -800w$$
$$8w^2 + 400w - 28\,000 = 0$$
$$w^2 + 50w - 3500 = 0$$

Using the quadratic formula:

$$w = \frac{-50 \pm \sqrt{50^2 - 4 \times 1 \times (-3500)}}{2} = \frac{-50 \pm \sqrt{16\,500}}{2}$$

Since $w > 0$, $w = \dfrac{-50 + \sqrt{16500}}{2} = 39.22\ldots$

The value of w is 39.2 (3 s.f.)