8. Calculation of how long wheel takes to complete one revolution:

Time = $2\pi \times 60$ m/0.20 m s^{-1} **(1)**

= 1900 s/1884 s/31.4 min **(1)** — 2

Change in passenger's velocity:

Direction changes OR up (N) $\rightarrow$ down (S) OR + $\rightarrow$ – **(1)**

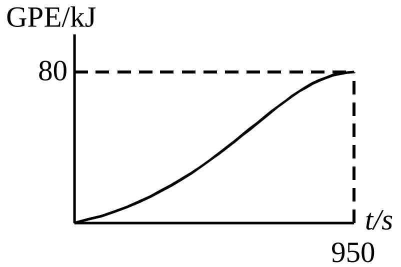
OR 180° **(1)** — 2

0.40 m s^{-1}
[0.40 m s^{-1} without direction = 2/2]

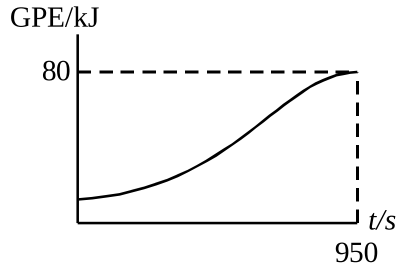
Calculation of mass:

(G)pe = mgh
$m = 80 \times 10^3$ J/9.81 m s^{-2} × 120 m) **(1)**
[This mark is for rearranging the formula; accept 10 instead **(1)**
of 9.81 and 60 instead of 120 but do not e.c.f. to next mark]
m = 68 kg **(1)** — 3

Sketch graph:



OR



Labelled axes and line showing PE increasing with time
Sinusoidal shape **(1)**
(950 s, 80 kJ) **(1)**
[Accept half the time they calculated at start of question **(1)**
instead of 950 s as e.c.f.]
[PE v h 0/3] — 3

Whether it is necessary for motor to supply the gpe:

No, because passenger on other side is losing gpe **(1)**
If wheel equally loaded OR balanced with people **(1)**

OR
Yes, because no other passengers **(1)**
so unequally loaded **(1)** — 2

[12]

9. Calculation of resultant force:

[$a = (\upsilon - u)/t$ = 16 m s^{-1}[(4 × 60) s]

= 0.0666 m s^{-2}

$F = ma$ = 84 000 kg × 0.0666 m s^{-2} = 5600 N]

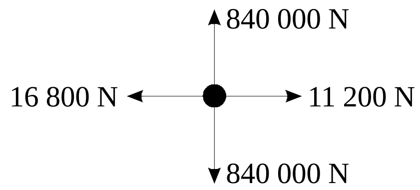
OR

Use of $\dfrac{(\upsilon - u)}{t}$ use of $m\upsilon$ **(1)**

Use of $F = ma$	use of $\frac{m\upsilon}{t}$	**(1)**	
5600 N	5600 N	**(1)**	3

Free-body force diagram:

Diagram [truck can be just a blob] showing:



823 200 – 840 000 N down		**(1)**	
same as down	up	**(1)**	
11 200 N	either way	**(1)**	
correct resultant	to left		
[e.c.f.]			
			4

[Ignore friction. Each extra force –1]

Calculation of average power:

Power = KE gained/time = ½mv^2/t	OR KE = 3.84×10^8 J	**(1)**	
= 3.84×10^8 J/(4 × 60) s		**(1)**	
= 1.60×10^6 W [OR J s^{-1}]		**(1)**	3

Other credit-worthy responses:

½ $m\upsilon^2$	Fv	$\frac{Fd}{t}$	**(1)**	
$\frac{1}{2} \times \frac{3\times10^6 \times 16^2}{240}$	$3 \times 10^6 \times 0.666 \times 8$	$\frac{3\times10^6 \times 0.666 \times 1920}{240}$ [e.c.f. 0.666 and 1920 possible]	**(1)**	
1.6×10^6 W	1.6×10^6 W	1.6×10^6 W	**(1)**	3

Calculation of average current:

$P = IV = I \times 25\,000$ V $= 1.60 \times 10^6$ W   Use of $P = IV$ 2

[12]

10. Completion of table:

Force	**Description of force**	**Body which exerts force**	**Body the force acts on**
A	Gravitational	Earth	Child
B	*(Normal) reaction OR contact OR E/M* **(1)**	*Earth/ground* **(1) for both**	*Child*
C	*Gravitational* [Not gravitational weight] **(1)**	*Child* **(1) for both**	*Earth*

4

Why *A* and *B* are equal in magnitude:

Child is at rest/equilibrium OR otherwise child would move/accelerate **(1)**
[NB use of N3 would contradict this]

Why must forces *B* and *D* be equal in magnitude:

Newton's third law OR action + reaction equal and opposite **(1)**
[NB use of N1 or N2 here would contradict this] [Not Newton pair] 2

What child must do to jump and why he moves upwards:

Push down, increasing *D* **(1)**

$\therefore$ *B* increases [must be clearly *B* or description of *B*] **(1)**

and is > *A* OR there is a resultant upward force [clearly on child] **(1)**
[Not "movement"] 3

[9]

11. Average force
multiplied by distance moved in direction of force 2

Work done negative when force is in opposite direction to displacement
Kinetic energy is reduced/gets less 2

Free body diagram:
Weight vertically downwards **(1)**
Produced by gravitational pull of Earth **(1)**
F (resistive force/drag) parallel to slope and upwards **(1)**
Produced by (friction with) snow/air **(1)** Max 3

Resultant force: zero
Work done by N: zero 2

[9]

12. <u>Free-body force diagram</u>
Normal reaction/contact force [or Nor R or push of table] upwards **(1)**
E-M/Magnetic force [or magnetic attraction or pull of magnet] to right **(1)**
Weight [or W or mg or gravitational force or gravitational attraction or pull of Earth] downwards **(1)** 3
[Ignore labelled forces of fiction. or drag] [if unlabelled −1 each force]

Forces
Pull on earth **(1)**
Upwards [consequent] **(1)**

OR

Push/contact force/force on table **(1)**
Downwards [consequent] **(1)**

OR

Force on magnet X **(1)**
To left [consequent] [allow ecf] **(1)** 2

[5]

13. Mass approximately 4 kg

Use of volume = $\pi r^2 \times h$ **(1)**

Use of mass = their volume above × density **(1)**

Mass = 3.75 (i.e. ≈ 4) [no u.e.] [Must be calculated to 2 significant figures at least] **(1)** 3

Calculation of change in g.p.e

Use of Δg.p.e = $mg\Delta h$ (ecf from above) **(1)**

39 – 44 J (positive or negative) **(1)** 2

Calculation of average power output

Use of Power = energy/time or use of $P = F\upsilon$ ($\upsilon = 1.8 \times 10^{-6}$ m s^{-1}) **(1)**

Correct conversion of time into seconds (604 800 s) **(1)**

$6.4 - 7.3 \times 10^{-5}$ W [e.c.f. gpe above] **(1)** 3

[Answer in J/day, J/week, J/hour – can get 2 marks, i.e.1st and 3rd marks]

[8]

14. Magnitude of resultant force

4 cm line S / 1.7 cm line N 1

8 cm line NE / 8N resolved into two perp. components (5.7E & 1.7N or 5.7N) 1

Correct construction for vector sum 1

5.7-6.1N 1

Name of physical quantities

Vectors 1

Two other examples

Any two named vectors other than force (if>2, must all be vectors) 1

[6]

15. Addition to diagram

Downwards arrow *Y* through middle third of left leg 1

Downward arrow *Z* with correct line of action 1

[Ignore lengths of arrows and point of action]
[Must have at least one correct label to get 2 marks; no labels gets max 1 out of 2]
[One correct label can get 2 marks]

Explanation

Quality of written communication 1

Clockwise moments = Anticlockwise when balanced 1

Y is smaller than *X*, but acts further from *P* 1

Moment of $X = X \times XP$ / Moment of $Y = Y \times YP$ 1

Z has little or no moment about P/Z acts through P 1

[7]

16. Resultant force

4 N to the right / 4 N with correct arrow **(1)** 1

Motion of object

(i) Constant velocity / $a = 0$ / constant speed **(1)**

(ii) Accelerates upwards **(1)**

(iii) Slows down **(1)** 3

Student's argument

The forces act on different bodies **(1)**

Therefore cannot cancel out / there is only one force acting on the body [consequent] 2

[6]

17. Table

Type of force	Example	
Gravitational	Weight/attraction between two masses	**(1)**
Electromagnetic	Normal reaction/friction/drag/tension/force between two charges or magnets/ motor effect/ elastic strain forces/contact forces	**(1)**
Nuclear	Strong/Weak/force keeping protons (and/or neutrons) together/beta decay/forces within nucleus	**(1)**

3

Forces

Any three from:

- same type **(1)**
- same magnitude/equal **(1)**
- act on different bodies/exerted by different bodies **(1)**
- opposite direction **(1)**
- same line of action **(1)**
- acts for same time **(1)** Max 3

[6]

18. Deceleration of trolley

Select $\upsilon^2 = u^2 + 2ax$ /both appropriate formulas **(1)**

Correct substitutions **(1)**

0.309 [2 significant figures minimum]**(1)** 3

Frictional force

Use of $F = ma$ **(1)**

8.7 / 8.6 N [8.4 if 0.3 used] **(1)** 2

Power

Use of $P = F\upsilon$ **(1)**

9.6 / 9.5 W [9.2 if 0.3 used] **(1)** 2

Force

Use of $a = (\upsilon - u)/t$ **(1)**

Add 8.6 /8.7 N to resultant force [8.4 if 0.3 used] **(1)**

42.8 N [42.6 if 0.3 used] [Accept 42.2 N] **(1)** 3

[10]

19. Criticism of statement

Not a Newton third law pair **(1)**

Forces in equilibrium but not for reason stated **(1)**

N3 pairs act upon different bodies **(1)**

N3 pairs same type **(1)**

Line of action different / rotation **(1)** Max 3

Table

Gravitational **(1)**

Earth **(1)**

Upwards **and** downwards [**both** must be correct] **(1)**

Table **(1)** 4

Force	Type of force	Direction of Newton 3^{rd} law 'pair' force	Body 'pair' force acts upon
Weight	Gravitational	Upwards	Earth
Push of table	Electro-magnetic	Downwards	Table

[7]

20. (a) Free body force diagram for magnet

(Electro)magnetic / (force of) repulsion / push **(1)**

Weight / W / mg / pull (of Earth) / gravitational (attractive force) / attraction (of Earth) **(1)** 2
[NOT gravity]
[An additional incorrect force cancels 1 mark awarded]

(b) Newton's third law pairs 6

Force	Body on which corresponding force acts	Direction of the corresponding force	
Contact	(Wooden) stand/base	Downwards / down / ↓	**(1) (1)**
Magnetic	(Magnet) M_1	Upwards / up / ↑	**(1) (1)**
Weight	Earth / Earth's surface	Upwards / up / ↑	**(1) (1)**

[8]

21. (a) Calculation of weight

Use of L × W × H **(1)**

Substitution into density equation with a volume and density **(1)**

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] **(1)** 3
[Allow 50.4(N) for answer if 10 N/kg used for g.]
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]
[Bald answer scores 0, reverse calculation 2/3]

$80 \text{ cm} \times 50 \text{ cm} \times 1.8 \text{ cm} = 7200 \text{ cm}^3$

$7200 \text{ cm}^3 \times 0.70 \text{ g m}^{-3} = 5040 \text{ g}$

$5040 \text{ g} \times 10^{-3} \times 9.81 \text{ N/kg}$

= 49.4 (N)

[May see :
$80 \text{ cm} \times 50 \text{ cm} \times 1.8 \text{ cm} \times 0.7 \text{ g m}^{-3} \times 10^{-3} \times 9.81 \text{ N/kg}$

= 49.4(N)]

(b) (i) Horizontal and vertical components

Horizontal component = (83 cos 37 N) = 66.3 N / 66 N **(1)**
Vertical component = (83 sin 37 N) = 49.95 N / 50 N **(1)** 2
[If both calculated wrongly, award 1 mark if the horizontal was identified as 83 cos 37 N and the vertical as 83 sin 37 N]

(ii) Add to diagram

Direction of both components correctly shown on diagram **(1)** 1

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] **(1)** 1
[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

[7]

22. (a) (i) Newton's First law of Motion

An object will remain (at rest or) uniform/constant velocity/speed/motion in a straight line unless (an external/impressed) force acts upon it / provided resultant force is zero. **(1)** 1

(ii) Everyday situation

Reference to air resistance / friction / drag etc. **(1)** 1

(iii) Equilibrium

The resultant force is zero / no net force /sum of forces is zero / forces are balanced / acceleration is zero **(1)** 1
[Accept moments in place of force]

(b) (i) Identify the other force

Earth **(1)**
Gravitational [consequent on first mark] [Do not credit gravity.] **(1)** 2

(ii) Why normal contact forces are not a Newton's third law pair

Do not act along the same (straight) line / do not act from the same point **(1)**
They act on the same body **(1)**
They act in the same direction / they are not opposite forces **(1)**
They are of different magnitudes **(1)**

max 2

[7]

23. (a) Complete statement of Newton's Third Law of Motion
....exerts an equal force on (body) A **(1)**

(but) in the opposite direction (to the force that A exerts on B) **(1)** 2
['exerts an equal but opposite force on body A' would get both marks]

(b) Complete the table

1 mark for each of the three columns **(1) (1) (1)** 3

[Accept from earth for up. Accept towards ground or towards earth for down]

	Earth	Gravitational. [**Not** 'gravity'. **Not** gravitational field strength]	Up(wards) / ↑
	Ground		Down(wards) / ↓

[5]