Mark schemes

1.

(a) friction

1

(b) (area of rectangle =) 108 (m)

1

(area of triangle =) 54 (m)

1

(total area / distance =) 162 (m)

allow a correctly calculated total area / distance from an incorrectly calculated area of rectangle and / or triangle

1

(c) (the force on the pedal) causes a moment about the pedal axle

1

which causes a force on the chain (which causes a moment about the rear axle)

allow gear B for chain

1

(d) $2.4^2 (- 0^2) = 2 \times a \times 18$

1

$$a = \frac{2.4 \times 2.4}{36}$$

1

$a = 0.16$ (m/s^2)

1

<u>alternative method</u>

t = 18 / 1.2
t = 15 (s) (1)

a = 2.4 / 15 (1)

this mark may be awarded if the time is incorrectly calculated

a = 0.16 (m/s^2) (1)

allow a correctly calculated acceleration from an incorrectly calculated time 1

(e) horizontal (200N) **and** vertical (75N) forces drawn to the same scale

1

resultant force drawn in the correct direction

shown by an arrow head from bottom right to top left

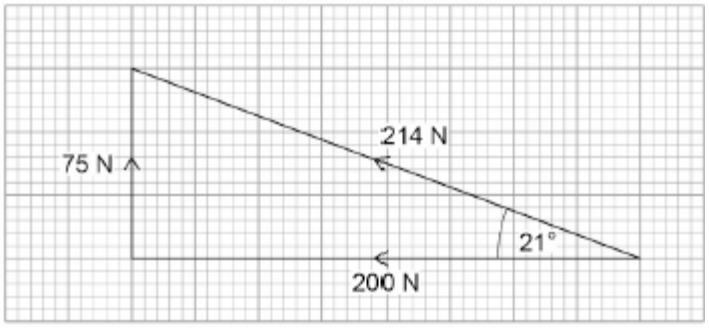
1

resultant force with a value in the range 212 to 218 (N)

allow a calculated value of 213.6 ***or*** *214 (N)*

1

direction in the range 20–22 (degrees from the horizontal)



allow 68–70 (degrees from the vertical)

allow a bearing in the range 290–292

to gain full marks a vector diagram must have been drawn

1

[13]

2. (a) (total) momentum before = (total) momentum after

allow (total) momentum stays the same

1

(b) momentum of player A = 585 (kg m/s)

1

momentum of player B = –500.5 (kg m/s)

1

$$\frac{(-500.5 + 585)}{(78 + 91)}$$

OR

$$\frac{84.5}{169}$$

allow $\frac{1085.5}{169}$

1

= 0.5 (m/s)

this answer only

1

(c) (protective pads) increase the time taken to stop (during the collision)

allow increases impact / contact / collision time
*do **not** allow slows down time*

1

so the rate of change of momentum decreases

allow reduces acceleration/deceleration
*allow increases the time to reduce the momentum to zero for **2** marks*

1

reducing the force (on the ice hockey player)

allow impact for force
*do **not** allow if linked to an incorrect explanation*

1

[8]

3.

(a) the tendency of an object to continue in its state of rest or motion

allow how difficult it is to change the velocity of an object

1

(b) (soft foam) increases the time taken to stop

allow increases impact/contact time

or

increases the time taken to decrease momentum

allow increases the time of the collision
*do **not** accept slows down time*

1

decreases the rate of change in momentum

allow reduces acceleration/deceleration
reduces momentum is insufficient
*allow increases the time to reduce the momentum to zero for **2** marks*

1

reducing the force (on the egg)

allow impact for force

1

(c)

*an answer 4.5 (m/s) scores **4** marks*

*an answer 4500 scores **3** marks*

180 ms = 0.18 s

if incorrectly or not converted, subsequent marks may still be awarded for correct method and calculations

1

$$800 = \frac{32 \times v}{0.18}$$

1

$$v = \frac{800 \times 0.18}{32}$$

1

v = 4.5 (m/s)

1

Alternative method

180 ms = 0.18 s (1)

Δmv = 144 (kgm/s) (1)

Δv = 144 ÷ 32 (1)

v = 4.5 (m/s) (1)

Alternative method

180 ms = 0.18 s (1)

a = 25 (m/s^2) (1)

25 = Δv ÷ 0.18 (1)

v = 4.5 (m/s) (1)

[8]

4. (a) longer arrow pointing vertically downwards

one arrow only

1

labelled weight

allow (force of) gravity

1

(b) initially air resistance is less than weight / gravity so the skydiver accelerates

allow drag for air resistance

allow increased velocity / speed for accelerates

1

acceleration causes the air resistance to increase

*acceleration **or** increased velocity / speed is not required here if given in the first mark point*

1

resultant force decreases to zero

allow air resistance becomes equal to weight / gravity

1

so the skydiver falls at terminal velocity

allow constant velocity/speed for terminal velocity
ignore any mention of subsequent motion and use of parachute

1

(c)

*an answer of 50 (m/s) scores **3** marks*

distance at 7s = 200 (m)
distance at 12s = 450 (m)

***both** distances required*

1

$$\text{speed} = \frac{450 - 200}{12 - 7} \text{ or } \frac{250}{5}$$

allow correct use of their two distances divided by 5

1

50 (m/s)

allow an answer consistent with their two distances

1

(d) The higher the altitude the less dense the air

1

so the air resistance on the skydiver (falling from 39000 m) was less (at the same speed)

1

so the skydiver was able to accelerate for longer before reaching (a higher) terminal velocity

allow constant velocity/speed for terminal velocity

1

or

so the skydiver was able to accelerate for longer before air resistance = weight / gravity

[12]

5. (a) air molecules colliding with a surface create pressure

1

at increasing altitude distance between molecules increases

or

at increasing altitude fewer molecules (above a surface)

1

so number of collisions with a surface decreases

or

or so always less weight of air than below (the surface)

1

(b) atmospheric pressure = 20 kPa from graph **and** conversion of 810 cm^2 to 0.081 m^2

allow ecf for an incorrect value clearly obtained from the graph

1

$5 \times 10^4 = \frac{F}{0.081}$

1

$F = 5 \times 10^4 \times 0.081$

1

4050

1

4100 (N)

1

*allow 4100 (N) with no working shown for **5** marks*

*allow 4050 with no working shown for **4** marks*

(c) force from air pressure acting from inside to outside bigger than force acting inwards

1

so keeps the window in position

1

[10]

6. (a) the (perpendicular) distance from the pivot / hinge to (the line of action of) the force is greater

allow distance from the rope to the pivot / hinge is greater (than distance between handle and pivot / hinge)

1

so a smaller force is required

this mark is dependent on scoring the 1st mark

*an answer a smaller force is required at the rope to produce the same moment scores **2** marks*

1

(b)

*an answer of 770 scores **6** marks*

924 = F × 0.15

1

F = 6160 (N)

allow use of E = ½ F e instead of k = F ÷ e and
E = ½ × k × e^2

1

6160 = k × 0.25

allow their calculated F = k × 0.25

1

$$k = \frac{6160}{0.25}$$

or

k = 24640 (N/m)

allow a value for k calculated using their calculated F

1

$$E = \frac{½ \times 6160 \times 0.25 \times 0.25}{0.25}$$

allow E = ½ × their calc. k × 0.25^2

1

E = 770 (J)

allow an answer consistent with their calculated k

1

[8]

7. (a) all heights drawn the same as tube 1

judge by eye

1

(b) increasing depth increases the height / mass / volume (of the water column) above the swimmer

allow more water above (the swimmer)
more water is insufficient

1

increasing the weight / force (of water) acting on the swimmer

1

(c) increase in depth = 1.2 (m)

1

(Δ) p = 1.2 × 1030 × 9.8

allow either 0.50 ***or*** *1.70 for 1.2*

1

(Δ) p = 12112.8

allow a correctly rounded answer
allow a correct calculation using either 0.50 ***or*** *1.70*

1

pascals **or** Pa

do ***not*** *accept pa*
allow N/m^2

1

an answer of 12 112.8 scores ***3*** *marks*

[7]

8. (a) arrow of equal size pointing vertically upwards

judged by eye
ignore horizontal arrows if equal and opposite
horizontal arrows of unequal length negates this mark

1

labelled 'upthrust'

ignore buoyancy
ignore 25 kN

1

(b) weight = 25 kN

allow 24 to 25 kN inclusive

1

25 000 = mass × 9.8
or
$m = \frac{25000}{9.8}$

allow their W correctly converted and substituted

1

m = 2551 kg

allow correctly calculated value using their converted W
allow a value correctly calculated with W in kN

1

m = 2600 kg

allow a calculated answer correctly rounded to 2 significant figures

1

an answer of 2600 scores ***4*** *marks*

(c) Newton's 3rd law (of motion)

1

(d) vertical force (50 N) drawn
and
horizontal force (150 N) drawn to the same scale

1

resultant tension force in the correct direction
shown by an arrowhead

1

value of the tension force in the range 156 N−160 N
allow a calculated value of 158

1

value of direction in the range 18°−20° (from the horizontal)
allow 70° to 72° (from the vertical)
allow a bearing in the range 288 to 290

1

[11]

9. (a) accept any value between 12 (mm) and 13 (mm) inclusive

1

(b) to reduce the error in measuring the extension of the spring
accept length for extension throughout

1

as the ruler at an angle would make the measured extensions shorter

1

(c) 1 (N) to 6 (N)
accept from 0 (N) to 6 (N)

1

(d) gives a straight line through the origin

1

(e) any practical technique that would improve the accuracy of length measurement eg

use a set square

1

to line up the bottom of the spring with the ruler scale

or

attach a horizontal pointer to the bottom of the spring (1)

so that the pointer goes across the ruler scale (1)

1

(f) the spring has been inelastically deformed

1

because it went past its limit of proportionality

accept elastic limit for limit of proportionality

1

accept it does not go back to its original length when the weights are removed

[9]

10. (a) distance is a scalar and displacement is a vector

or

distance has magnitude only, displacement has magnitude and direction

1

(b) 37.5 km

accept any value between 37.0 and 38.0 inclusive

1

062° or N62°E

accept 62° to the right of the vertical

1

accept an angle in the range 60° −64°

accept the angle correctly measured and marked on the diagram

(c) train changes direction so velocity changes

1

acceleration is the rate of change of velocity

1

(d) number of squares below line = 17

accept any number between 16 and 18 inclusive

1

each square represents 500 m

1

distance = number of squares × value of each square correctly calculated − 8500 m

1

[8]

11. (a) the distance travelled under the braking force

1

(b) the reaction time will increase

1

increasing the thinking distance (and so increasing stopping distance)

(increases stopping distance is insufficient)

1

(c) No, because although when the speed increases the thinking distance increases by the same factor the braking distance does not.

1

eg

increasing from 10 m / s to 20 m / s increases thinking distance from 6 m to 12 m but the braking distance increases from 6 m to 24 m

1

(d) If the sled accelerates the value for the constant of friction will be wrong.

1

(e) only a (the horizontal) component of the force would be pulling the sled forward

1

the vertical component of the force (effectively) lifts the sled reducing the force of the surface on the sled

1

(f) $-u^2 = 2 \times -7.2 \times 22$

award this mark even with 0^2 and / or the negative sign missing

1

$u = 17.7(99)$

1

18

1

*allow 18 with no working shown for **3** marks*

*allow 17.7(99) then incorrectly rounded to 17 for **2** marks*

[11]