**M1.**(a)      *3 lines drawn
all correct
allow* ***1*** *mark for each correct line
if two or more lines are drawn from any diagram then all these lines are incorrect*

**

**3**

(b)     (i)      horizontal arrow to the right

*judge by eye*

*accept an arrow drawn outside the box if it is labelled correctly*

**1**

(ii)     horizontal arrow to the left

*judge by eye*

*accept an arrow drawn outside the box if it is labelled correctly*

**1**

(iii)    equal to

**1**

(iv)     to measure the forces exerted on the dummy during the impact

**1**

**[7]**

**M2.          B** and **D** (either order)

**1**

**B** and **D** (either order)

*accept* ***A*** *and* ***C***

**1**

          **A** or **C**

**1**

**[3]**

**M3.**          (a)     gravity

**1**

(b)     air resistance

**1**

(c)          bigger than

**1**

accelerates downwards

**1**

*correct order only*

**[4]**

**M4.**(a)     turning

**1**

(b)     420

*allow* ***1*** *mark for correct substitution, ie 1400 × 0.30 provided no subsequent step shown*

**2**

(c)     **A**

*reason only scores if A is chosen*

**1**

any **one** correct reason:

the force is furthest away (from the pivot)

*accept distance (from the pivot) is the greatest*

*accept it is further away (from the pivot)*

*accept furthest away from the rock*

**1**

**[5]**

**M5.**          (a)     below

**1**

(b)     boss

**1**

nail

*do* ***not*** *allow boss*

**1**

string

**1**

(c)     (i)      line from mid-point of either side to the mid-point of the opposite side

*intention correct as judged by eye, use of ruler not essential*

*do* ***not*** *allow either diagonal*

**1**

(ii)     **X** in the centre of the rectangle

**1**

**[6]**

**M6.**(a)     (i)      friction

**1**

(ii)     air resistance

*accept drag*

*friction is insufficient*

**1**

(iii)    Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a ‘best-fit’ approach to the marking.

**0 marks**

No relevant content.

**Level 1 (1–2 marks)**

There is an attempt to explain in terms of forces A and B why the velocity of the cyclist changes between any two points
**or**a description of how the velocity changes between any two points.

**Level 2 (3–4 marks)**

There is an explanation in terms of forces A and B of how the velocity changes between X and Y and between Y and Z
**or**a complete description of how the velocity changes from X to Z.
**or**an explanation and description of velocity change for either X to Y or Y to Z

**Level 3 (5–6 marks)**

There is a clear explanation in terms of forces A and B of how the velocity changes between X and Z
**and**a description of the change in velocity between X and Z.

**examples of the points made in the response**

***extra information***

**X to Y**

      •        at X force A is greater than force B

      •        cyclist accelerates

      •        and velocity increases

      •        as cyclist moves toward Y, force B (air resistance)
      increases (with increasing velocity)

      •        resultant force decreases

      •        cyclist continues to accelerate but at a smaller value

      •        so velocity continues to increase but at a lower rate

**Y to Z**

      •        from Y to Z force B (air resistance) increases

      •        acceleration decreases

      •        force B becomes equal to force A

      •        resultant force is now zero

      •        acceleration becomes zero

      •        velocity increases until…

      •        cyclist travels at constant / terminal velocity

*accept speed for velocity throughout*

**6**

(b)     (i)      3360

*allow* ***1*** *mark for correct substitution,*

*ie 140 × 24 provided no subsequent step*

*accept 3400 for* ***2*** *marks if correct substitution is shown*

**2**

joule / J

*do* ***not*** *accept j*

*do* ***not*** *accept Nm*

**1**

(ii)     decreases

*accept an alternative word / description for decrease*

*do not accept slows down*

**1**

temperature

*accept thermal energy*

*accept heat*

**1**

**[13]**

**M7.**(a)     3800

*allow* ***1*** *mark for 2000*

*allow* ***1*** *mark for 1800*

*if neither of above scored, allow correct substitution for* ***1*** *mark (800 × 2.5) + (600 × 3)*

*if moments have been calculated incorrectly, allow 1 mark for adding their two moment values correctly*

**3**

newton metres **or** Nm

*do* ***not*** *allow nm* ***or*** *NM*

**1**

(b)     as the girl increases her distance (from the pivot) the clockwise moment increases

**1**

(F must increase) as the anticlockwise moment must increase

**1**

so (the anticlockwise moment) is equalled / balanced by the clockwise moment
**or**so resultant / overall moment (on the board) is zero

*accept to balance / equal the moments*

*to balance the board is insufficient*

**1**

**[7]**

**M8.**(a)     (i)     120

**1**

(ii)     20

*accept 140–their (a)(i) provided answer is not negative*

**1**

(iii)    as speed increases

**1**

drag force / water resistance / friction / **D** increases

**1**

(until) **D** = 140 N or (until) **D** = **T**

*forces balance is insufficient*

**1**

(b)     (i)      (average) speed (of swimmer)

**1**

(ii)     any **two** from:

•    more data

*accept results for data*

*do* ***not*** *accept more accurate data*

•    force may vary (a lot) / change

•    give more reliable average

*ignore references to anomalies*

*ignore accurate / precise*

**2**

(iii)    examples of acceptable responses:

•    most / some females produce smaller forces

*do* ***not*** *accept all females produce smaller forces*

•    most / some males produce larger forces

*do* ***not*** *accept all males produce larger forces*

•    some females swim as fast as males but use a smaller force

•    most of the faster swimmers are male

*do* ***not*** *accept all males swim faster*

•    most of the slower swimmers are female

*do* ***not*** *accept all females swim slower*

•    range of the (average) speed of males is smaller than the     range of the (average) speed of females

•    range of the (average) force of the males is greater than the     range of the (average) force of the females

**1**

(iv)     exert maximum (hand) force (throughout the swim / stroke)

*accept (any method to) increase (hand) force*

*practise more is insufficient*

**1**

**[10]**

**M9.**          (a)     *idea that*      balanced by friction force\* / pushing force equals
friction force (\*note “balanced” by unspecified force)
**or**specification of relevant force but no reference to balancing
in both 1(a) and 1(b) gains 1 mark overall

*for 1 mark*

**1**

(b)     balanced by upwards force of table\*

*for 1 mark*

**1**

(c)     makes it (slightly) warm / hot
**or**wears it away (slightly) / damages surface

*for 1 mark*

**1**

**[3]**

**M10.**(a)     the forces are equal in size and act in opposite directions

**1**

(b)     (i)       forwards / to the right / in the direction of the 300 N force

*answers in either order*

**1**

accelerating

**1**

(ii)     constant velocity to the right

**1**

(iii)    resultant force is zero

*accept forces are equal / balanced*

**1**

so boat continues in the same direction at the same speed

**1**

(iv)    parallelogram or triangle is correctly drawn with resultant
 

**3**

value of resultant in the range 545 N – 595 N

*parallelogram drawn without resultant gains* ***1*** *mark*

*If no triangle or parallelogram drawn:*

*drawn resultant line is* ***between*** *the two 300 N forces gains* ***1*** *mark*

*drawn resultant line is between and longer than the two 300 N forces gains* ***2*** *marks*

**1**

**[10]**

**M11.**          (a)     (i)      centre of **X** directly below **P** and between the model aeroplanes

*as judged by eye but between centre of propeller of top aeroplane and canopy of bottom aeroplane*

*example*

**

**1**

(ii)     the centre of mass is (vertically) below the point of suspension / P

**1**

         the centre of mass is in the middle of the aeroplanes

*accept the centre of mass is level with the aeroplanes*

**1**

(b)     centre of mass of the worker and the ladder (and device)

**1**

          line of action of the weight is inside the base

*accept the centre of mass is above / within / inside the base (of the ladder and device)*

**1**

          so there will not be a (resultant) moment

*accept so he / it / the ladder will not topple even if he leans over*

          **or** it will (only) topple over if the line of action of the weight / the
centre of mass is outside the base

*accept each point, either on the diagram or in the written explanation, but do* ***not*** *accept the point if there is any contradiction between them*

**1**

**[6]**

**M12.**(a)     (i)      the line of action of the weight (of the bus) lies / acts outside of the base (of the bus)

*allow line of action through the centre of mass lies / acts outside the base*

**1**

there is a resultant moment (acting on the bus)

**1**

(ii)     in normal use the centre of mass may be in a different position

**1**

**or**

passengers on the bus may affect the position of the centre of mass

for safety, buses should always be tested beyond the normal operating conditions / parameters

*for safety is insufficient*

*accept in case something unexpected happens*

**1**

(b)     (i)      a liquid is (virtually) incompressible

*accept a liquid cannot be squashed*

*a liquid is difficult to compress is insufficient*

**1**

(ii)     84000

*award* ***2*** *marks for*

**

***or***

**

***or*** *award* ***1*** *mark for*

**

***or***

*300 000 (Pa)*

*seen anywhere*

**3**

**[8]**

**M13.**(a)     suspend shape from a point / pivot / pin

*can be shown on labelled diagram*

**1**

attach pendulum (bob) / plumb line to point of suspension

**1**

draw (vertical) line on card where string rests

**1**

suspend card from another point and draw (a second vertical) line on card where string rests

**1**

where two lines cross = centre of mass

*alternative method max* ***3*** *marks:*

*balance card on a point (1)*

*find point where card rests horizontally (1)*

*this point is the centre of mass (1)*

**1**

(b)     (i)      (the line of action of) the weight acts / lies outside the base

*reference to centre of mass unqualified is insufficient*

**1**

there will be a resultant moment

*references to stability insufficient*

**1**

(ii)     move the wheels further apart

*answers must be comparative to diagram*

*accept any method that would give a wider base*

*accept tilt the wheels*

*accept on own, make a wider base but not wider seat*

**1**

lower the seating position

*accept any method that would lower the centre of mass, eg place heavy mass under the chair*

*accept on own make it have a lower centre of mass*

*make wheelchair heavier on its own is insufficient*

**1**

**[9]**

**M14.**          (a)     1.25

*allow* ***1*** *mark for correct resultant force ie 1500N*

*allow* ***2*** *marks for correct transformation and substitution*

*ie *

*allow* ***1*** *mark for a correct transformation but clearly substituting an incorrect value for force*

*eg = *

**3**

m/s 2

**1**

(b)     as speed increases so does the size of the drag force

*accept frictional force / resistive force / air resistance for drag*

**1**

eventually the drag force becomes equal to the thrust

**1**

the resultant force is now equal to zero and therefore
there is no further acceleration

**1**

(c)     the car and van will reach top speed when the forward
force equals the drag force

*accept air resistance / frictional / resistive force for drag force*

**1**

the drag force at any speed is smaller for the car than
for the van

**1**

as the car is more streamlined

**1**

therefore the car’s drag force will equal the forward force
at a higher speed

**1**

*allow converse throughout*

**[11]**

**M15.**          (a)     1.2

*allow* ***1*** *mark for conversion of 2.4 kN to 2400 N*

*or for correct transformation without conversion*

*ie d = 2880 ÷ 2.4*

**2**

metre(s)/m

**1**

(b)     any **two** from:

•        as the load increases the (total) clockwise moment increases

•        danger is that the fork lift truck / the load will topple / tip forward

•        (this will happen) when the total clockwise moment is
equal to (or greater than) the anticlockwise moment

*accept moments will not be balanced*

•        (load above 10.0 kN) moves line of action (from C of M)
outside base (area)

**2**

**[5]**

**M16.**          (a)     47250

*answers of 1350/ 33750/ 48600 gain* ***1*** *mark
allow* ***1*** *mark for correct substitution using both 18 and 3*

**2**

(b)     (i)      47250 or their (a)

*accept statement ‘same as the KE (lost)’*

*ignore any units*

**1**

(ii)     transformed into heat/ thermal energy

*sound on its own is insufficient
accept transferred/ lost/ for transformed
do* ***not*** *accept any other form of energy included as a list*

**1**

**[4]**

**M17.**(a)     38 400

*allow 6.4 × 6000 for* ***1*** *mark*

**2**

Nm **or** newton metres

*do* ***not*** *credit ‘nm’, ‘mN’ or ‘metre newtons’*

**1**

(b)      16 000 (N) **or** 16 kN

*allow* ***1*** *mark for 38 400 ÷ 2.4*

*accept their (a) ÷ 2.4 correctly calculated for* ***2*** *marks*

*accept their (a) ÷ 2.4 for* ***1*** *mark*

**2**

**[5]**

**M18.**(a)     (i)      turning

*accept turning ringed in the box*

**1**

(ii)     point at which mass (or weight) may be thought to be concentrated

*accept the point from which the weight appears to act*

*allow focused for concentrated*

*do* ***not*** *accept most / some of the mass*

*do* ***not*** *accept region / area for point*

**1**

(b)     600 (Nm)

*400 × 1.5 gains* ***1*** *mark provided no subsequent steps shown*

**2**

(c)     (i)      plank rotates clockwise

*accept girl moves downwards*

*do* ***not*** *accept rotates to the right*

**1**

(total) CM > (total) ACM

*accept moment is larger on the girl’s side*

**1**

weight of see-saw provides CM

*answer must be in terms of moment*

*maximum of* ***2*** *marks if there is no reference to the weight of the see-saw*

**1**

(ii)     W = 445 (N)

*W × 1.5 = (270 × 0.25) + (300 × 2.0) gains* ***2*** *marks*

*allow for* ***1*** *mark:*

*total CM = total ACM either stated or implied*

***or***

*(270 × 0.25) + (300 × 2.0)*

*if no other marks given*

**3**

**[10]**

**M19.**(a)     (i)      **X** placed at 50 cm mark

**1**

(ii)     point at which mass of object may be (thought to be) concentrated

**1**

(b)     (i)      **Y** placed between the centre of the rule and the upper part of mass

**1**

(ii)     16.5

*allow for* ***1*** *mark
(16.5 + 16.6 +16.5) / 3*

**2**

1.65

*value consistent with mean value given*

*only penalise significant figures once*

**1**

(iii)    Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should apply a ‘best-fitߣ approach to the marking.

**0 marks**No relevant content

**Level 1 (1 – 2 marks)**A description of a method which would provide results which may not be valid

**Level 2 (3 – 4 marks)**A clear description of a method enabling some valid results to be obtained. A safety factor is mentioned

**Level 3 (5 – 6 marks)**A clear and detailed description of experiment. A safety factor is mentioned. Uncertainty is mentioned

**examples of the physics points made in the response:**

**additional apparatus**

•        stopwatch

**use of apparatus**

•        measure from hole to centre of the mass

•        pull rule to one side, release

•        time for 10 swings and repeat

•        divide mean by 10

•        change position of mass and repeat

**fair test**

•        keep other factors constant

•        time to same point on swing

**risk assessment**

•        injury from sharp nail

•        stand topple over

•        rule hit someone

**accuracy**

•        take more than 4 values of *d*

•        estimate position of centre of slotted mass

•        small amplitudes

•        discard anomalous results

•        use of fiducial marker

**6**

(c)     (i)      initial reduction in *T* (reaching minimum value) as *d* increases

**1**

after 30 cm *T* increases for higher value of *d*

**1**

(ii)     (no)

any **two** from:

•        fourth reading is close to mean

•        range of data 0.2 s / very small

•        variation in data is expected

**2**

**[16]**