1 (a) (i) weight of container (= mg = 22000 × 9.8(1)) = 2.16×10^5 (N) **(1)**

tension (= ¼ *mg*) = (5.39) 5.4×10^4 (N) or divide a weight by 4 **(1)**

(ii) moment (= force × distance) = 22000 *g* × 32 **(1)** ecf weight in (a) (i)

= 6.9 or 7.0×10^6 **(1)** **N m** or correct base units **(1)** not J, nm, NM

(iii) the counterweight **(1)**

provides a (sufficiently large) anticlockwise moment (about Q)
or moment in opposite direction (to that of the container to
prevent the crane toppling clockwise) **(1)**

or
left hand pillar pulls (down) **(1)**
and provides anticlockwise moment

or
the centre of mass of the crane(‘s frame and the counterweight)
is between the two pillars **(1)**

which prevents the crane toppling **clockwise**/to right **(1)**

7

(b) (i) (tensile) stress $\left(= \frac{\text{tension}}{\text{csa}}\right) = \frac{5.4 \times 10^4}{3.8 \times 10^{-4}}$ ecf (a) (i) **(1)**

= $1.4(2) \times 10^8$ **(1)** **Pa** (or N m^{-2}) **(1)**

(ii) extension = $\frac{\text{length} \times \text{stress}}{E}$ or $\frac{FL}{EA}$ **(1)**

= $\frac{25 \times 1.4 \times 10^8}{2.1 \times 10^{11}}$ and (= 1.7×10^{-2} m) = 17 (mm) **(1)**

5

[12]

2 (a) (i) force × perpendicular distance **(1)**

between line of action of force and the point **(1)**

2

(ii) rear **(1)**

at rear + idea that centre of mass is closer to the rear wheel
(than to the front wheel) **(1)**

2

(iii) $14000 \times 1.4 = F \times 2.5$ **(1)**

F = 7840 (N) **(1)**

divides their final answer by 2 **(1)**

= 3900 (N) **(1)** (3922)

4

(b) ($F = k\Delta l$) $\frac{F}{k}$ or (Δl =) $\frac{\text{(a)(iii)}}{100000}$ **(1)**

= 0.039 (m) **(1)** ecf

2

(c) F = (100000 × 0.065 =) 6500 (N) **(1)**

F = (2 × 6500) = 13000 (N) **(1)**

2

[12]

3 (a) any **two** from

freefall is too quick (any indication of slower motion) **(1)**

(Galileo had) no (accurate) method to **time** freefall (or valid comment regarding timing of freefall or inclined plane) **(1)**

correct reference to **air** resistance or **drag** (not 'wind') **(1)**

max 2

(b) (i) 0.20 × 9.81 = 1.962 (N) **(1)**

(1.962 sin 1.8 =) 0.0616 or 0.062 seen **(1)** (allow 0.061)
(0.0628 for use of g = 10 gets 1 mark)

2

(ii) 0.06(16)/0.20

or use of $a = F/m$ with a clearly identified force but not the weight

or g sinθ = g sin 1.8° **(1)**

0.31 (m s^{-2}) **(1)** (0.308)

accept 0.3 or 0.30 correct answer only for second mark

or ($a = 2s/t^2$)

= $2 \times 0.29/1.4^2$ **(1)** = 0.31 **(1)** or use of other values from table

2

(c) accelerating **(1)** (accept increasing speed, etc but not increasing acceleration/quicker motion, etc)

greater distance for each additional swing ('per unit time' must be implied) or gradient/ steepness/ slope increasing **(1)** (accept curves upwards)

2

(d) **tangent used:**

tangent drawn at 3.0 m ± 0.3 on graph **(1)**

their time from graph × 1.4 **(1)**

= 1.28 to 1.44 (m s^{-1}) **(1)**

or suvat used:

use of $v = \frac{2s}{t}$ or $v = (u) + at$ with a from (b) (ii) **(1)**

(t =) 4.4 to 4.5 (s) **(1)**

(speed =) 1.3 to 1.4 (m s^{-1}) **(1)**

3

[11]

4 (a) (sum of) clockwise moment**s** (about a point) =(sum of) anticlockwise moment**s** **(1)**

(for a system) in equilibrium **(1)**

accept balanced not stationary

2

(b) (780 × 0.35 =) 270 (Nm) **(1)** (273)

Nm (1) or newton metre(s) accept Newton metre(s)
(not J, nm or nM, Nms, etc)

2

(c) (b) + (1100 × 0.60) **(1)**

(=) F_A × 1.3 **(1)** (F_A = 660 + 273/1.3 gets both marks)

(= 933/1.3) = 720 (N) **(1)** (717.7 or 715 for use of 930)

ecf (b)

2 sf only (1)

independent mark

4

(d) (780 + 1100 – (c)) = 1200 **(1)** (1162 N)

ecf (c)

1

(e) $\left(F = \frac{P}{v}\right) = \frac{7.5(\times 10^3)}{26}$ **(1)**

must be arranged in this form

= 290 (N) **(1)** (288.46)

2

[11]

5 (a) (i) (one) **force** × distance between the **forces** ✓

(one) **force** × **perpendicular** distance between the **lines of action** or (one) **force × perpendicular** distance between the (two) **forces** ✓

2

(ii) (810 × 7.3 =) 5900 (5913) (or alternative correct method)

Nm ✓

2

(b) *P* = *Fv* = (2 ×) 810 × 0.91 ✓

(1620 × 0.91) = 1500 ✓ (1474 W)

any number to 2 sf ✓

3

(c) to enable comparison between steam and horses

or mill owners/engineers etc needed to know which steam engine would be suitable

or would easily be able to compare the cost/time saved

or good marketing ploy for steam engines

or easily understood (by industrialists or the public)

or other suitable valid reason ✓

1

[8]

6 (a) (i) 180000 × 2.8 ✓

= 500000 ✓ (504000 Nm) ecf from first line for incorrect power of 10

2

(ii) 7.4 × lift fan thrust ✓

= 180000 × 2.8 (504000 Nm) ✓ ecf from part ai

F = 68000 or 68 k (N) ✓ (68108 N) ecf

3

(iii) 180k − 68.1k = (111.9 =) 112 k (N) ✓ ecf from part aii

or by taking moments

1

(b) (i) ($m = W/g$) = 180 000/9.81 ✓ (= 18349 kg)

$a = F/m$ = 155 000/18349 = 8.4 ✓ (8.4475 ms^{-2})
ecf for use of 180 in 1st mark

use of weight rather than mass gets zero

2

(ii) **cross-sectional or surface** area / shape / streamlining / aerodynamics / nature of surface / drag coefficient ✓

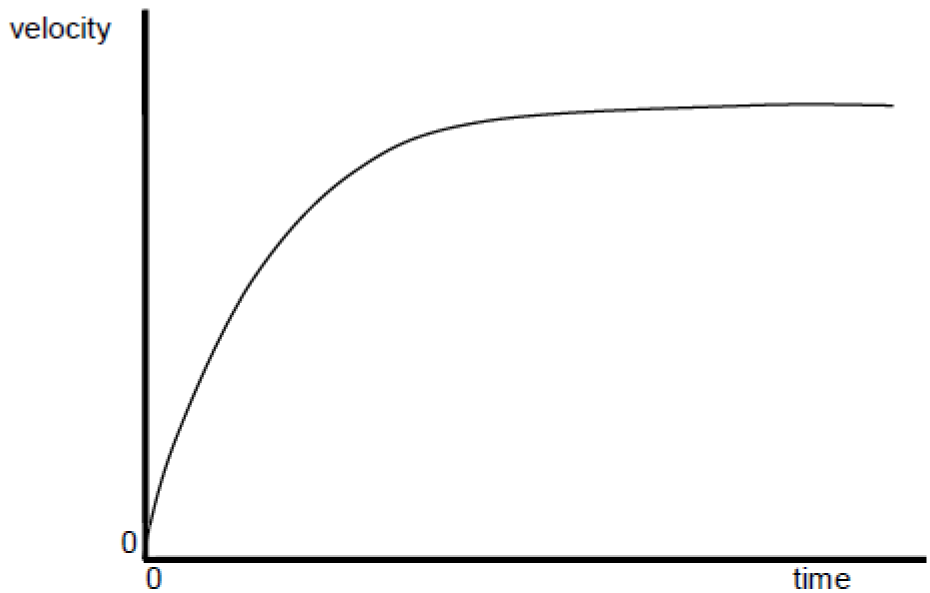
correctly linked to its effect on air resistance/drag ✓

or maximum thrust/force power of engine ✓

counterforce increases with speed

or when drag equals thrust (forces are balanced) ✓

2



line starting at zero and **curving with decreasing gradient** ✓

reaching a constant velocity ✓

2

(c) steepest/maximum gradient ✓

1

[13]

7 **C**

[1]

Examiner reports

1 A surprisingly large number of candidates divided the mass by four to get a .weight. of 5500 kg in part (a) (i). Many also forgot to divide by four in what should have been a fairly uncomplicated question.

In part (a) (ii), many candidates simply multiplied the mass of 22000 kg by 32, indicating a surprising confusion between weight and mass. For the unit mark there were many common errors such as N, NM, Nm^{-1}, Nm^{-2}, J, nm, kg and Nkg^{-1}.

A very easy mark for mentioning the .counterweight. was picked up by most candidates in part (a) (iii). However, not many went on to discuss the .anticlockwise moment. that this provides.

Most picked up the first two marks to part (b) (i), some as a result of the ecf for the tension. Many candidates used wrong units; pa, PA, Nm^{-1}, being common rather than Pa.

Those with an ecf in (b) (i) generally failed to get both marks to part (b) (ii) because they did not arrive at 17 mm. This may have given some candidates a clue that one of their previous answers was incorrect. The candidates who were successful on the first parts of the question invariably scored both marks here.

2 In part (a) (i), the majority of candidates stated 'force × perpendicular' distance but only 16% stated the full definition. Many did not recall the definition accurately or did not say the distance was between the line of action of the force and the point. Many said 'force × perpendicular distance from the line of action' or 'force × perpendicular distance to the point'. These candidates were only awarded one mark. A significant number of candidates stated the Law of moments rather than the definition of a moment and some produced a vague description of a turning effect rather than a definition. Students should be encouraged to learn the full definition off by heart.

In part (a) (ii) 57% scored two marks very easily. However, a surprising number selected the front springs rather than the rear due to 'a larger distance from the pivot causing a greater moment on the front'; confusing the *centre of mass* with the 'pivot'. Some candidates assumed the *centre of mass* is always closer to the front of a truck. However, the question shows a rear-engined pick-up. Some candidates thought that the rear springs were 2.0 m from the *centre of mass* having incorrectly interpreting the dimensions on the diagram. Some felt that since the truck was in equilibrium, both sets of springs would be equally compressed.

For such a simple moments question, part (a) (iii) was done poorly by the majority. Perhaps the context made it seem more difficult than it really was, but many chose the wrong distances and equated a moment with a force rather than another moment. Common incorrect answers were 14000 × 1.4 = 19600 and 14000 × 1.4 = 14000 × 1.1. Many common answers given were greater than the weight of the truck. Most of those who couldn't pick up any marks for the moments calculation did realise that it would be necessary to divide by two at the end and so most scored at least one mark.

In part (b) most gained two marks with the error carried forward from their previous answer.

The poor response to part (c) was very surprising. Only 5% gained two marks with 47% getting zero and 18% not attempting the question. Perhaps those who had struggled on previous parts of this question made the assumption that this would be difficult as it was the final part of the question. However, it was perhaps the easiest part of the question and was independent of the previous parts.

3 In part (a), candidates did not have to have encountered Galileo's method for investigating freefall to be successful. Many showed awareness that either air resistance would not be a significant factor or that timing would be easier due to the lesser speeds when using an inclined plane.

Considerably less than half candidates were able to resolve to find the component of the weight acting down the slope in part (b) (i). Some used just the mass rather than mg and this response gained zero marks.

Part (b) (ii) was a straight forward use of $a = F/m$ and the majority of candidates gained full marks.

In part (c), many candidates thought the trolley was accelerating at an increasing rate because of the upward curve. Some did not use the term 'acceleration' in their answer and some thought that the rate of acceleration was decreasing because the curve was getting straighter. The data plotted on the graph does not support the view that the acceleration decreases. The distance between each pendulum swing increases in such a way to support uniform acceleration.

A very large majority of candidates did not recall that the gradient of a distance time graph gives the speed in part (d). Most of these calculated the average speed using $v = s/t$ with $s = 3.0$ and $t = 3.15 \times 1.4$ rather than the instantaneous speed at 3.0 m.

4 This question was perhaps easier than the moments question on the January paper, as the context was much simpler. However June 2009's paper featured a calculation of a moment but no use of the principle of moments.

In part (a), candidates were asked to state the Principle of Moments. A relatively small number of candidates managed to gain both marks. We accepted 'lockwise moment **s** equal anticlockwise moment**s** when balanced' as the minimum to gain both marks. If we had insisted on a more strict definition including the phrases 'um of' and 'equilibrium' the percentage gaining full marks would have dropped to less than 10%.

It was surprising to find that so many students had not remembered to learn this definition. Improving candidate' recall of definitions such as this is clearly an area that could be worked on by many centres. A large number of candidates gave the definition of a moment instead of the principle of moments and many simply gave a vague description of the topic.

For part (b), quite a few candidates did not read the question and calculated the moment of bike and rider together or they chose the wrong distance. Candidates were often confused about the unit of moment. The most common errors seen were N or Nm^{-1}.

Part (c) was a straight forward moments calculation. It was very similar to a question set in January and the number of candidates scoring zero marks decreased significantly in comparison to the January paper. Those who struggled on this question appeared not to know the difference between a moment and a force. A common incorrect approach was to calculate the 'force' by adding together the two anticlockwise moments.

It was also surprising that only small number of candidates understood that the answer should be stated to two significant figures. Indeed this seems to have been a problem across all of the papers on this specification.

Many students believed that rounding a number reduces the 'accuracy', and it is very difficult to shift this belief. However, students need to be persuaded that the lack of precision is in the measurements given in the question, and their final answer should not exceed this precision.

The final answer should have the same number of significant figures as the quantity used that has the smallest number of significant figures. It can help if students are encouraged to write down the answer as it appears on their calculators and then give the rounded answer on the answer line.

A common error was to assume that each tyre would experience the same force in part (d). Many candidates who had been unsuccessful on the previous question did pick up this mark for employing the correct method.

The majority of candidates found part (e) very easy and relatively few missed the 'k' in kW.

5 Very few candidates knew the definition in part (a)(i). Many gave a vague description of a *couple*. Most simply defined a *moment* and these responses received no credit.

Despite not having known the definition of a moment of a couple, many went on to successfully calculate it in part (a)(ii). A few calculated 810 × d/2, instead of simply 810 × d. A significant number of candidates dropped marks by giving incorrect units. Typical errors were: N, Nm^{-1}, NM, and nm.

Many candidates got the calculation correct in part (b) though some did not multiply by two to take in to account the two horses. A significant number wrongly multiplied the torque (instead of the power) by the velocity to get 5400. A significant figure mark was applied to this question and a significant amount of candidates did not round to two significant figures; needlessly losing one mark.

Many candidates came up with very sensible answers in part (c). This requires that candidates 'analyse and evaluate scientific knowledge and processes'. Therefore, the question required a little bit of thinking around science.

Very few candidates missed the question out. Many understood that a comparison was being made between steam engines and horses due to the widespread familiarity with the capabilities of the horse at that time.

6

Part (a) (i) was very straightforward and most students scored two marks. Some scored zero by attempting a moments calculation. There were a few mixn-ups with powers of ten; some thought that kN was 10^6 N and some did not spot k.

Many students used 4.6m rather than 4.6 + 2.8 = 7.4m to calculate the moment of the lift-fan force in part (a) (ii). There is still a lot of confusion with moments questions for students in the January paper, and the evidence may suggest that many schools have not practised enough of these.

The maths of this question could not be made much simpler apart from perhaps giving the 7.4m dimension on the diagram. It was again apparent that a large number of students believed a complicated solution must be required; perhaps the context persuaded them that this must be so. However, once the candidate has simplified the diagram, the question is straightforward and simply dividing their previous answer by 7.4 yields all three marks. Given the frequency of this style of question on PHYA2 papers, it is really worth going over as many of these as possible with students.

The weight of the aircraft minus the engine thrust previously calculated yielded the mark for most students in part (a) (iii). However, a significant number did not know this or used the law of moments again.

In part (b) (i) a very large number of students used a=*F/m* with the weight of the aircraft used for mass. This approach did not gain any marks. Many rounded their mass before using it to calculate the acceleration, this was forgiven in this question, as was the use of g = 10 ms^{-2}. These errors are condoned here because we do not penalise the same mistake several times in a paper.

In response to part (b) (ii), many students did not realise they had to state a characteristic of the aircraft. This meant referring to the shape or aerodynamics in some way or the maximum thrust. Marks could not be scored unless one of these was mentioned. There seemed to be a common misconception that 'its air resistance' was a characteristic of the plane. The question was interpreted by many as 'explain why the plane reaches a terminal velocity'. Many believed that the mass of the aircraft would be a factor. However, the mass would limit the acceleration rather than the top speed.

In part (b) (iii), examiners were looking for an understanding that the acceleration would be falling towards zero as the terminal velocity was approached. Many students recognised that the velocity would increase and then remain constant. However, a very large proportion of students drew a straight diagonal line with an abrupt change to constant velocity. There were also many 's' shaped curves and curves that showed the acceleration continually increasing. Many also drew straight diagonal lines that did not 'level off'.

Part (c) was an easy question but students did not read it well and many lost the mark because they simply stated that the maximum acceleration is the gradient rather than the **maximum** gradient. A large number also believed that the area represents the acceleration or that the gradient at maximum velocity would be the maximum acceleration. Note that the response; 'the part of the graph where the gradient is steepest' does not make it clear that the gradient = the acceleration.

Many students lost the mark because they said the maximum acceleration was the initial gradient. This would apply to the graph in part (b) (iii) but it was not enough for the mark. Some students responded that 'the gradient of the flat part of the graph' should be found.

7 Almost 40% of students were able to select the correct answer. The most common wrong answer selected was B; here students used a simple 2:1 ratio approach for the distance based on the information provided about the tensions.