Moments AS Revision Pack

Name: ____________________

Class: ____________________

Date: ____________________

Time: **203 minutes**

Marks: **172 marks**

Comments:

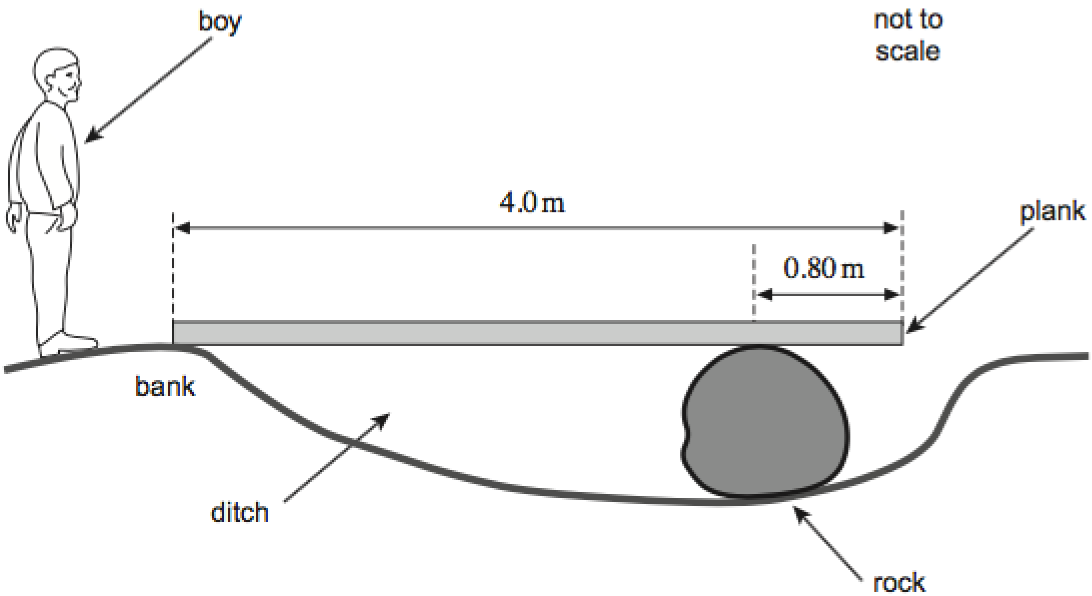
1 (a) State what is meant by the centre of mass of an object.

____

____

(1)

(b) A uniform plank of wood of mass 32 kg and length 4.0 m is used by a boy to help him cross a ditch. In the ditch is a rock, which is used to support the plank horizontally 0.80 m from one end, as shown in the diagram. The other end of the plank is supported by the bank.



Calculate the vertical supporting force from the rock when the plank is placed in position as shown in the diagram.

supporting force = ____________________ N

(2)

(c) The boy has a mass of 46 kg.

Determine whether the boy can walk to the far end of the plank without it tipping. Support your answer with a calculation.

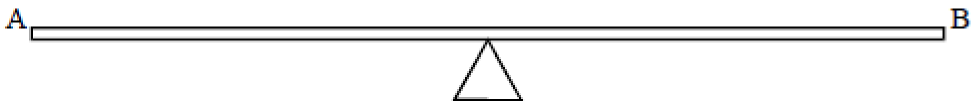
(3)

(Total 6 marks)

2 (a) State the principle of moments.

(2)

(b) The diagram shows a uniform metre ruler, AB, freely pivoted at its centre of mass.



Explain what is meant by the centre of mass.

(1)

(c) A 1.0 N weight is placed on the ruler 0.30 m from the middle of the ruler towards A.

(i) Explain which way the pivot must be moved in order for equilibrium to be restored.

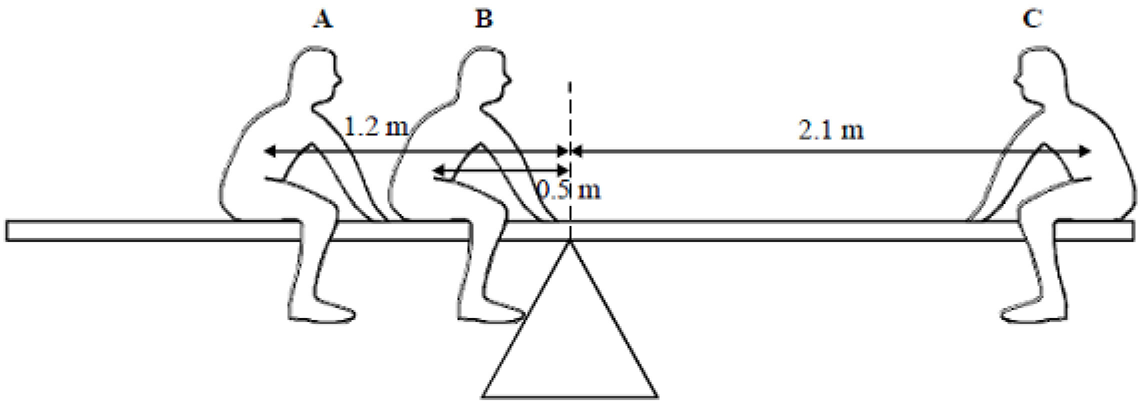
(ii) Calculate the distance the pivot needs to be moved to restore equilibrium when the weight of the ruler is 0.50 N.

(5)

(Total 8 marks)

3 The diagram below shows three children **A**, **B** and **C** sitting on a balanced, horizontal see-saw of mass 35 kg. The centre of mass of the see-saw is vertically above the pivot.

A has a weight of 650 N and **B** has a weight of 550 N. **A** sits 1.2 m from the pivot and **B** sits 0.5 m from the pivot of the see-saw.



(a) **C** sits 2.1 m from the pivot.

By taking moments about a suitable point, calculate the weight of **C**.

Weight of **C** ____________________

(3)

(b) Calculate the force on the pivot of the see-saw.

gravitational field strength of Earth, g = 9.8 N kg^{-1}

Force on pivot ____________________

(2)

(Total 5 marks)

4 (a) The torque of a couple is given by

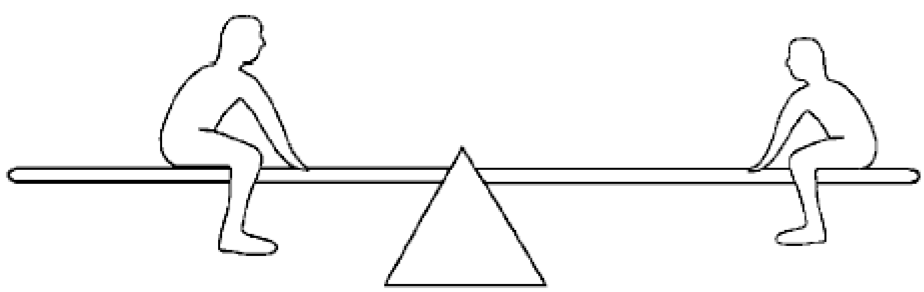
torque = Fs.

(i) With the aid of a diagram explain what is meant by a couple. Label F and s on your diagram.

(ii) State the unit for the torque of a couple.

(4)

(b) The see-saw shown in the diagram consists of a uniform beam freely pivoted at the centre of the beam. Two children sit opposite each other so that the see-saw is in equilibrium.



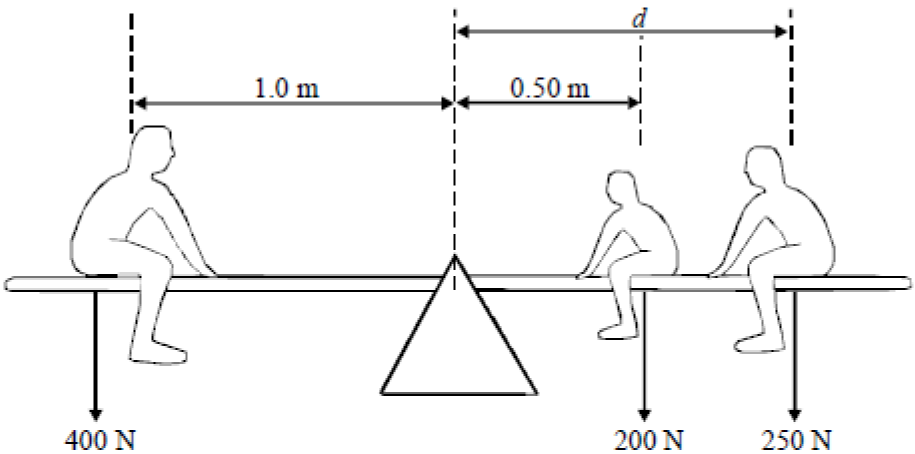
Explain why

(i) the see-saw is in equilibrium,

(ii) the weight of the beam does not affect equilibrium.

(3)

(c) The diagram shows the see-saw with three children of weights 400 N, 250 N and 200 N sitting so that the see-saw is in equilibrium.



Calculate the distance, d.

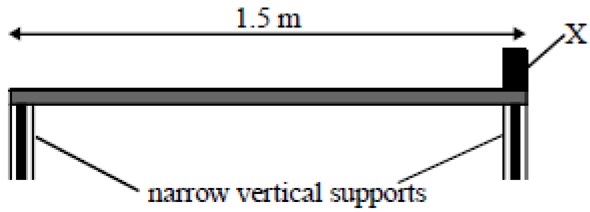
(2)

(Total 9 marks)

5 (a) State the principle of moments.

(2)

(b) (i) A uniform plank of length 1.5 m and mass 9.0 kg is placed horizontally on two narrow vertical supports as shown. A block, X, of mass 3.0 kg is placed at the end of the plank immediately above the centre of the right-hand support.



Calculate the magnitude of the downward force on

the right-hand support, ____

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____

____

the left-hand support ____

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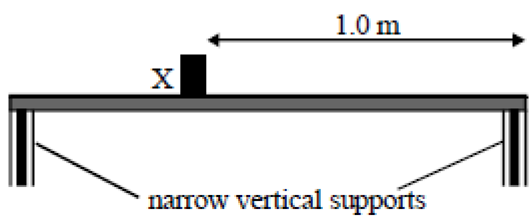
(ii) The block X is now moved so that its centre of mass is immediately above a point 1.0 m from the right hand edge of the plank.



Calculate the magnitude of the downward force on

the right-hand support, ____

____

____

____

____

the left-hand support ____

____

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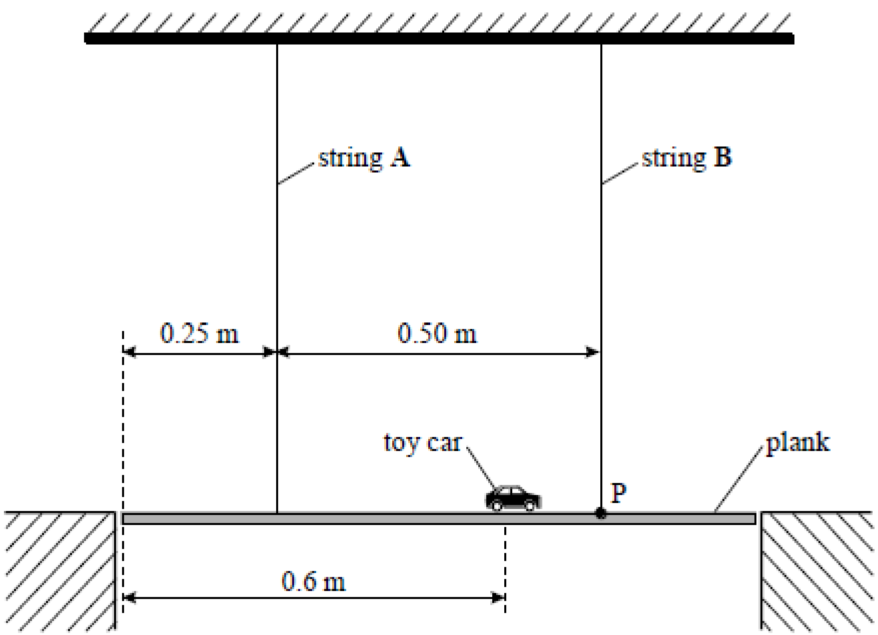
(6)

(Total 8 marks)

6 (a) Define the moment of a force about a point.

(2)

(b) The diagram below shows a model bridge consisting of a uniform plank of wood. The plank is 1.0 m long and weighs 10 N. A toy car of weight 5 N is placed on it. The bridge is suspended from a rigid support by two strings and is in equilibrium. The plank does not touch the shaded blocks.



(i) Show and label the forces acting on the bridge.

(2)

(ii) By taking moments about point **P**, calculate the tension in string **A**.

(3)

(iii) Calculate the tension in string **B**.

(1)

(Total 8 marks)

7 (a) State the principle of moments.

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(2)

(b) **Figure 1** shows a student of weight 550 N doing a “press up”. In the position shown the body is horizontal and the forearms are vertical.

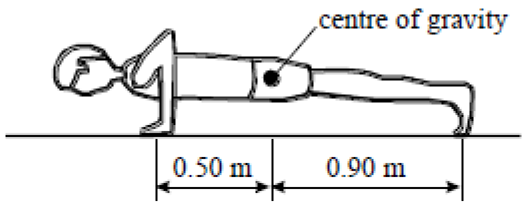


Figure 1

Assuming that each arm experiences the same force and that the forces acting on each foot are equal, calculate the compression force acting:

(i) in each of the student’s forearms;

(2)

(ii) on each of the student’s feet.

(1)

(c) Another student attempts the same exercise but with the forearms at an angle of 30° to the ground, as shown in **Figure 2**.

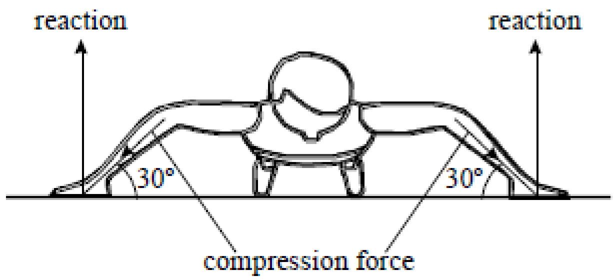


Figure 2

(i) The directions of some of the forces acting on the hands have been indicated. Indicate, on **Figure 2**, any other forces acting on the hands

(1)

(ii) State the cause of these additional forces.

____

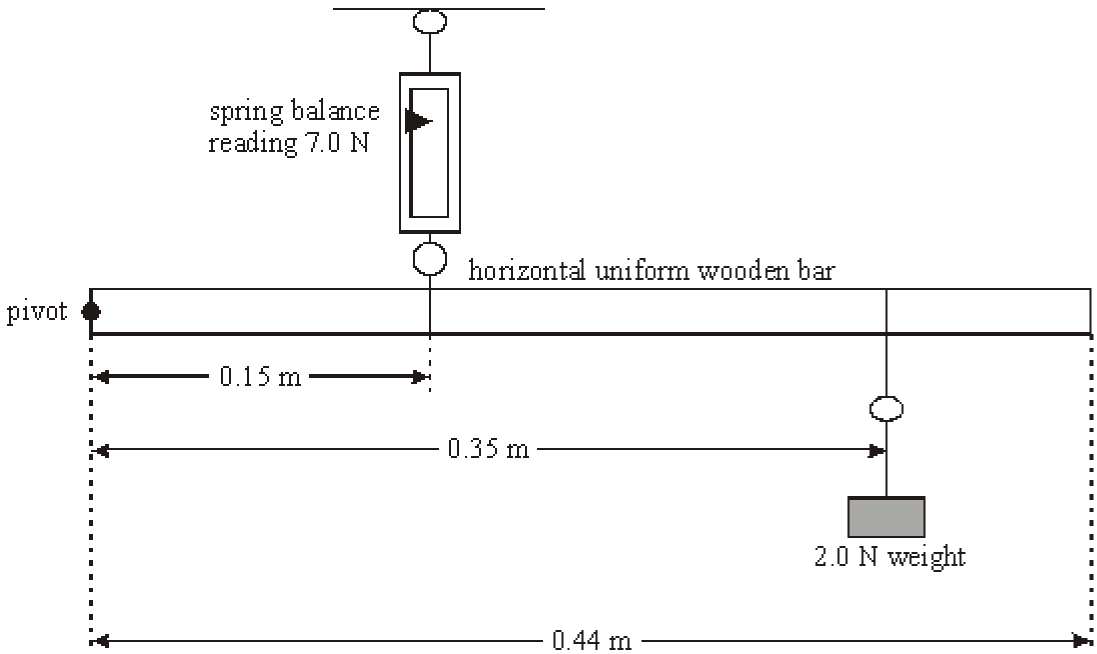
(1)

(iii) The reaction force at each hand is 210 N. Calculate the magnitude of the compression force in each forearm in this position.

(1)

(Total 8 marks)

8 A student set up the apparatus shown in the figure below to demonstrate the principle of moments.



(a) Using the values on the figure calculate:

(i) the magnitude of the moment about the pivot due to the tension of the spring in the spring balance;

moment due to spring tension ____________________

(1)

(ii) the magnitude of the moment about the pivot produced by the 2.0 N weight;

moment due to 2.0 N weight ____________________

(1)

(iii) the weight of the wooden bar.

weight ____________________

(1)

(b) (i) Calculate the magnitude of the force exerted on the bar by the pivot.

magnitude of force ____________________

(1)

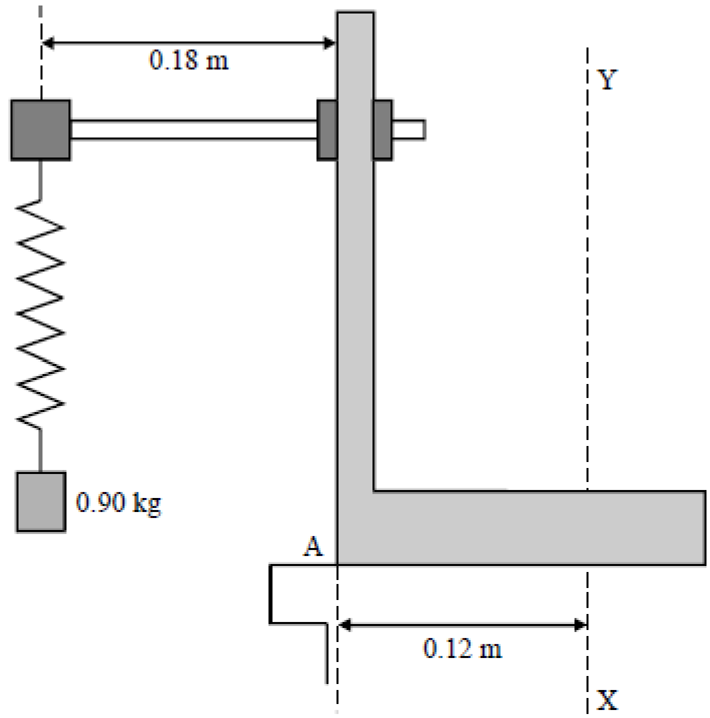
(ii) State the direction of the force on the pivot.

____

(1)

(Total 5 marks)

9



The mass of a retort stand and clamp is 1.6 kg and their combined centre of mass lies along the line XY. A spring which has a negligible mass is attached to the clamp and supports a mass of 0.90 kg, as shown in the diagram. The spring requires a force of 6.0 N to stretch it 100 mm.

(a) Calculate the extension of the spring.

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____

(2)

(b) Show that this arrangement will not tip (i.e. will not rotate about A) when the 0.90 kg mass is at rest in its equilibrium position.

____

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____

____

(2)

(c) If the mass is lifted up and released, it will vibrate about the equilibrium position. Explain, without calculation, why the stand will tip if the amplitude exceeds a certain value.

____

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____

(3)

(Total 7 marks)

10 (a) Define the moment of a force about a point.

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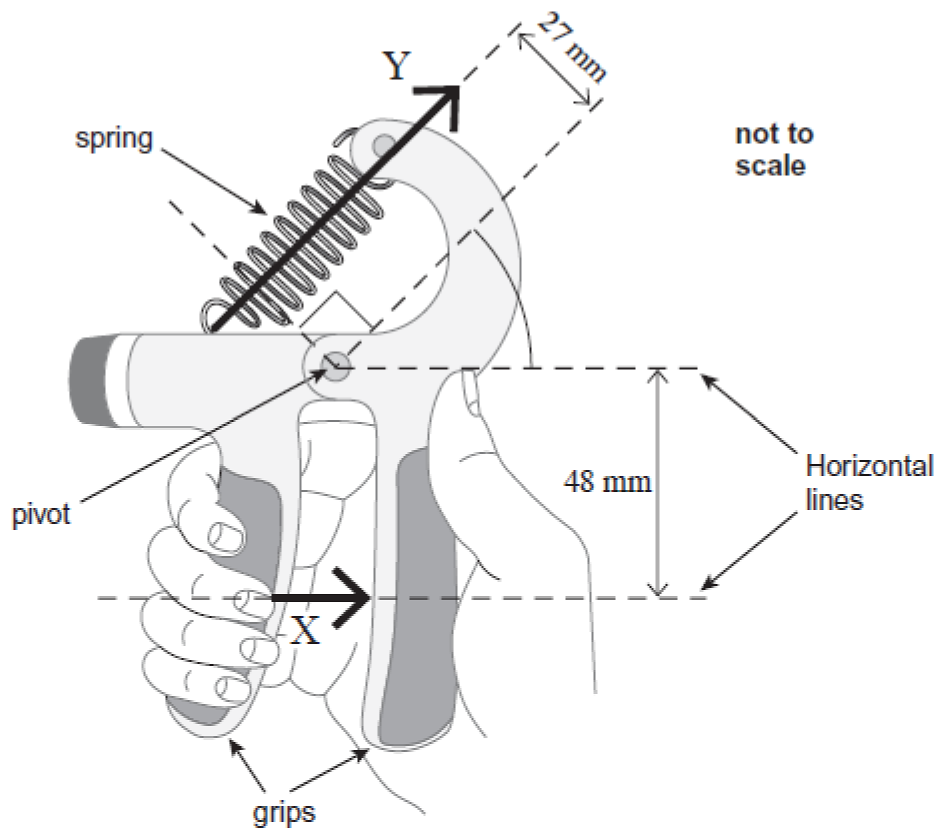
(2)

(b) The diagram shows a gripper which is used for hand strengthening exercises.



The diagram shows the gripper being squeezed. In this situation, the gripper is in equilibrium. The force produced by the fingers is equivalent to the single force **X** of magnitude 250 N acting in the direction shown above. A force, **Y**, is exerted by the spring which obeys Hooke's law.

(i) Calculate the moment of force **X** about the pivot. State an appropriate unit.

moment = ____________________ unit __________

(2)

(ii) Calculate force **Y**.

force = ____________________ N

(2)

(iii) The extension of the spring is 15 mm.

Calculate the spring constant k of the spring. Give your answer in N m^{-1}.

spring constant = ____________________ N m^{-1}

(2)

(iv) Calculate the work done on the spring to squeeze it to the position shown in the diagram.

work done = ____________________ J

(2)

(Total 10 marks)

11 (a) State the principle of moments.

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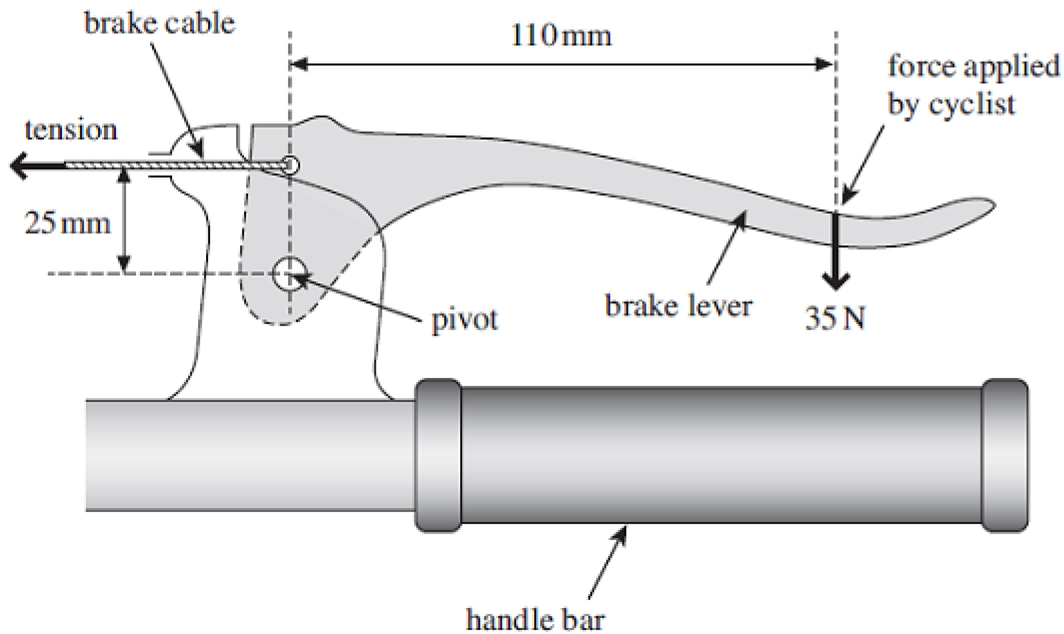
(3)

(b) The diagram below shows a bicycle brake lever that has been pulled with a 35 N force to apply the brake.



(i) Calculate the moment of the force applied by the cyclist about the pivot. State an appropriate unit.

moment = ____________________ unit __________

(3)

(ii) Calculate the tension in the brake cable. Assume the weight of the lever is negligible.

tension = ____________________ N

(3)

(c) In order to maintain a constant velocity of 15 ms^{-1} downhill, the cyclist applies the brake. The power developed by the braking force is 2.8 kW.

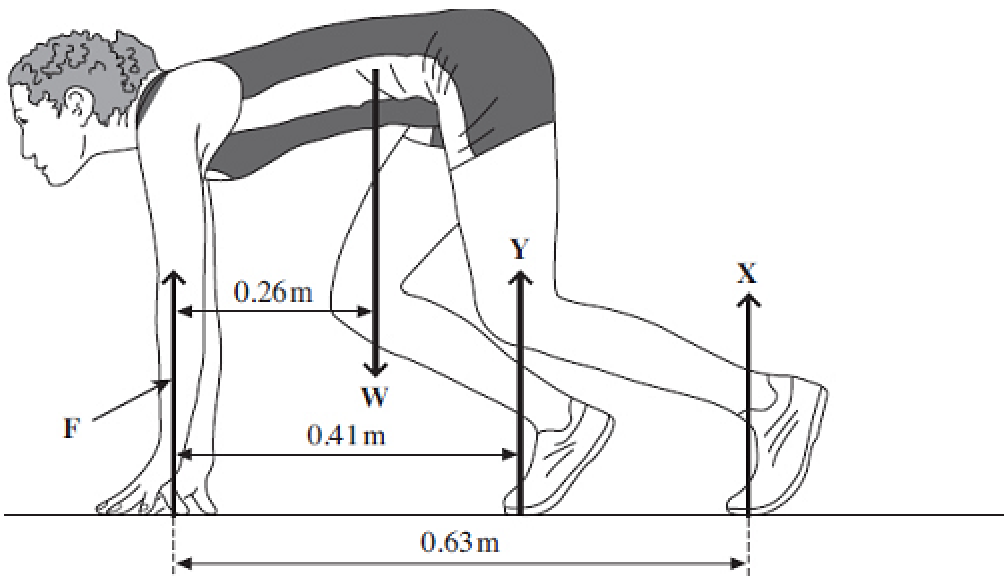
Calculate the total average frictional force between the brake blocks and the wheel rim.

frictional force = ____________________ N

(2)

(Total 11 marks)

12 A sprinter is shown before a race, stationary in the 'set' position, as shown in the figure below. Force **F** is the resultant force on the sprinter's finger tips. The reaction force, **Y**, on her forward foot is 180 N and her weight, **W**, is 520 N. **X** is the vertical reaction force on her back foot.



(a) (i) Calculate the moment of the sprinter's weight, **W**, about her finger tips. Give an appropriate unit.

answer = ____________________ unit __________

(2)

(ii) By taking moments about her finger tips, calculate the force on her back foot, marked **X**.

answer = ____________________ N

(3)

(iii) Calculate the force **F**.

answer = ____________________ N

(1)

(b) The sprinter starts running and reaches a horizontal velocity of 9.3 ms^{-1} in a distance of 35 m.

(i) Calculate her average acceleration over this distance.

answer = ____________________ $m\ s^{-2}$

(2)

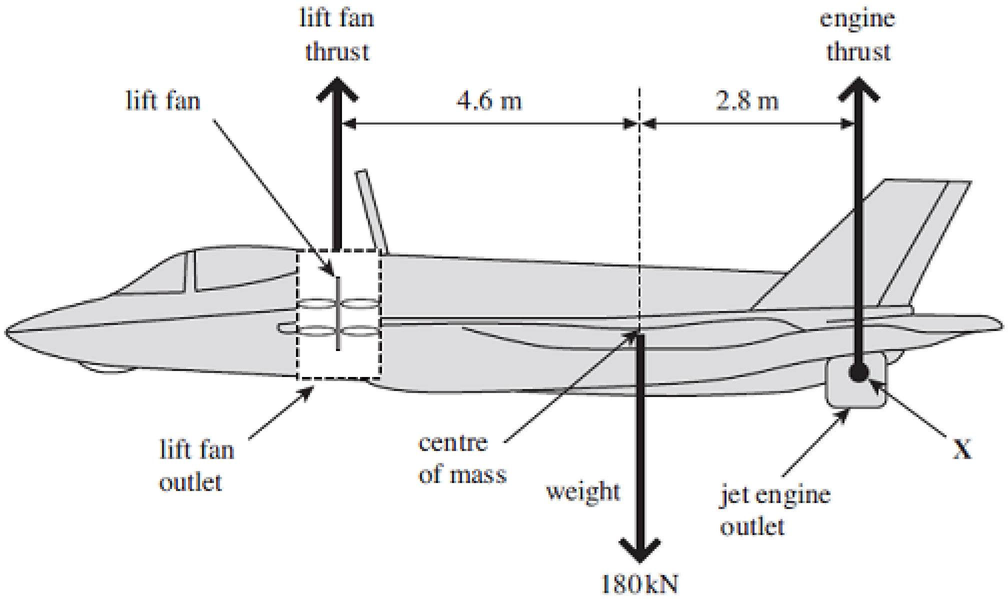
(ii) Calculate the resultant force necessary to produce this acceleration.

answer = ____________________ N

(2)

(Total 10 marks)

13 The figure below shows an aircraft designed to take off and land vertically and also to hover without horizontal movement. In order to achieve this, upward lift is produced by directing the jet engine outlet downwards. The engine also drives a vertical lift fan near the front of the aircraft. The weight of the aircraft is 180 kN. The distance between the lift fan and the centre of mass is 4.6 m and the distance between the jet engine outlet and the centre of mass is 2.8 m.



(a) (i) Calculate the moment caused by the weight of the aircraft about the point **X**.

answer = ______________________ Nm

(2)

(ii) By taking moments about **X**, calculate the lift fan thrust if the aircraft is to remain horizontal when hovering.

answer = ______________________ N

(3)

(iii) Calculate the engine thrust in the figure above.

answer = ______________________ N

(1)

(b) Having taken off vertically, the jet engine outlet is turned so that the engine thrust acts horizontally. The aircraft accelerates horizontally to a maximum velocity. The forward thrust produced by the jet is 155 kN. The weight of the aircraft is 180 kN.

(i) When the resultant horizontal force is 155 kN, calculate the horizontal acceleration of the aircraft.

answer = ______________________ ms^{-2}

(2)

(ii) State and explain **one** characteristic of the aircraft that limits its maximum horizontal velocity.

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____

(2)

(iii) On the axes below, sketch the velocity-time graph for the horizontal motion of the aircraft as it accelerates from zero to its maximum horizontal velocity.

(2)

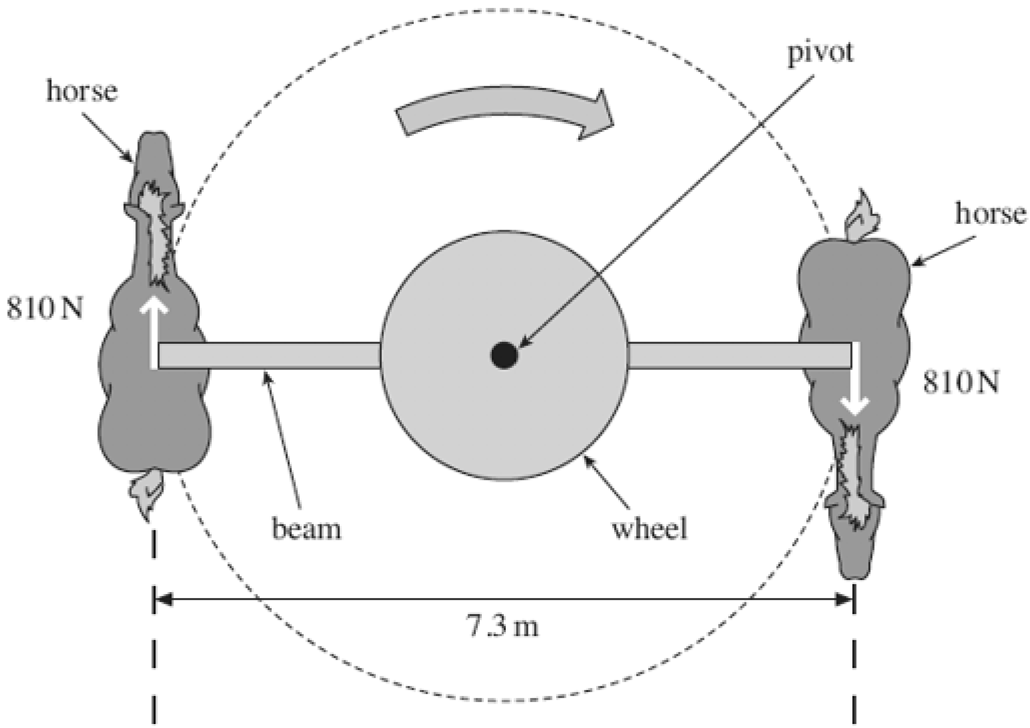
(c) State how a velocity-time graph could be used to find the maximum acceleration.

____

(1)

(Total 13 marks)

14 Horses were once used to power machinery in factories, mines and mills. The figure below shows two horses attached to a beam which turns a wheel. This wheel drives machinery.



(a) Each horse exerts a force of 810 N and the length of the beam is 7.3 m.

(i) Define the moment of a couple.

____

____

____

(2)

(ii) Calculate the moment of the couple exerted by the horses, stating an appropriate unit.

answer = ________________________

(2)

(b) The horses move at a constant speed of $0.91 ms^{-1}$. Calculate the combined power output of the two horses. Give your answer to an appropriate number of significant figures.

answer = ______________________ W

(3)

(c) During the Industrial Revolution in the 19th Century, James Watt became well known for developing and improving steam engines to replace horses. He defined the unit of power called '*horsepower*' by studying a system similar to the one shown in the figure above.

Suggest why Watt decided to use *horsepower* as a unit of power.

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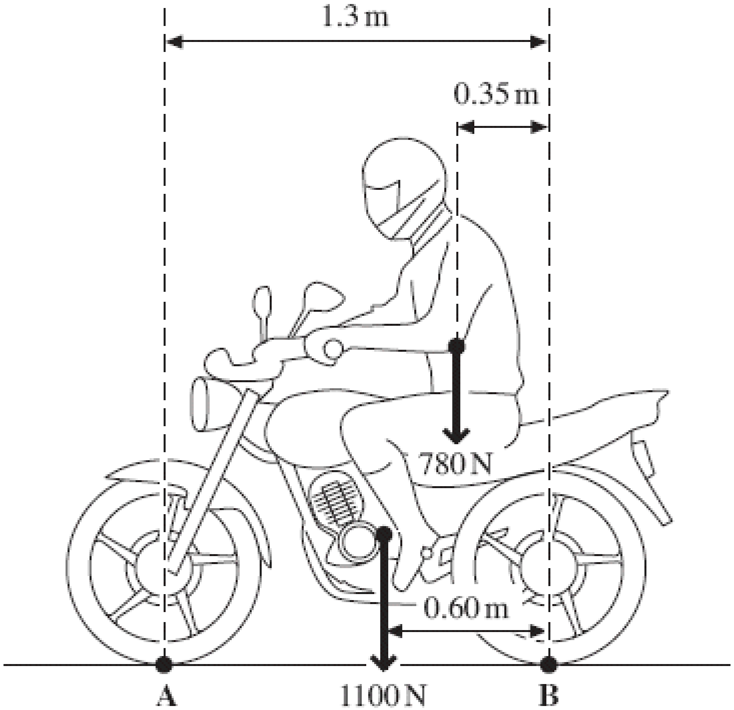
(1)

(Total 8 marks)

15 The figure below shows a motorcycle and rider. The motorcycle is in contact with the road at **A** and **B**.



The motorcycle has a weight of 1100 N and the rider's weight is 780 N.

(a) State the Principle of Moments.

___

___

___

(2)

(b) Calculate the moment of the rider's weight about **B**. Give an appropriate unit.

answer = ______________________

(2)

(c) By taking the moments about **B**, calculate the vertical force that the road exerts on the front tyre at **A**. State your answer to an appropriate number of significant figures.

answer = ______________________ N

(4)

(d) Calculate the vertical force that the road exerts on the rear tyre at **B**.

answer = ______________________ N

(1)

(e) The maximum power of the motorcycle is 7.5 kW and it has a maximum speed of 26 m s^{-1}, when travelling on a level road.

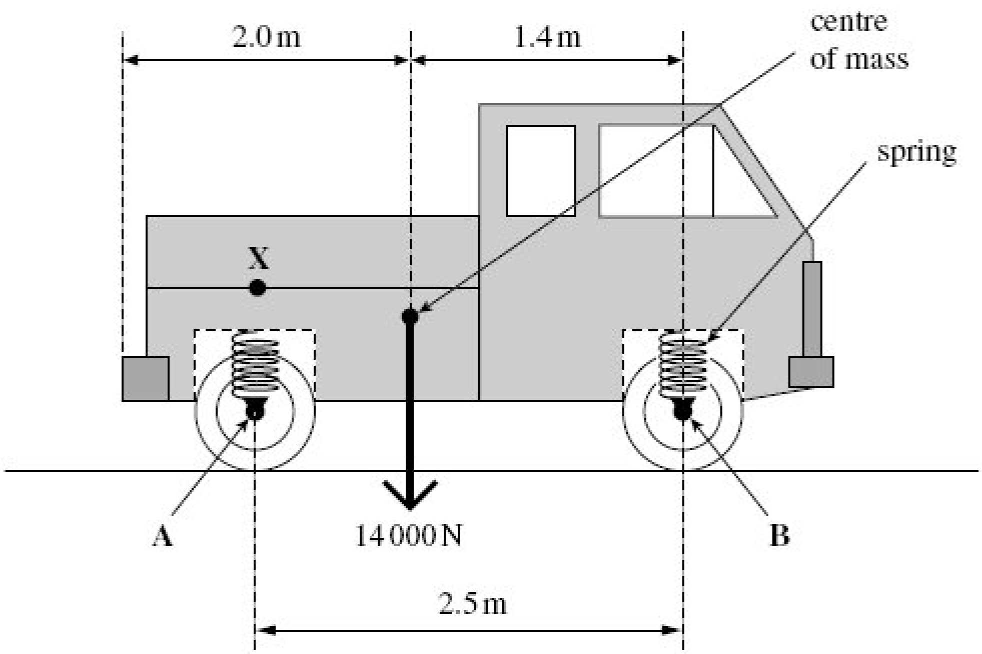
Calculate the total horizontal resistive force for this speed.

answer = ______________________ N

(2)

(Total 11 marks)

16 Heavy duty coil springs are used in vehicle suspensions. The pick-up truck shown in the diagram below has a weight of 14 000 N and length of 4.5 m. When carrying no load, the centre of mass is 2.0 m from the rear end. The part of the vehicle shown shaded in grey is supported by four identical springs, one near each wheel.



(a) (i) Define the moment of a force about a point.

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____

____

____

(2)

(ii) State and explain which pair of springs, front or rear, will be compressed the most.

____

____

____

____

(2)

(iii) By taking moments about axle **B**, calculate the force exerted on the truck by each rear spring.

answer = ____________________ N

(4)

(b) The spring constant for each of these springs is 100 000 N m^{-1}.

Calculate the distance that each of these rear springs is compressed by this vehicle as shown in the diagram above.

answer = ____________________ m

(2)

(c) The springs must not be compressed by more than an additional 0.065 m. Calculate the maximum load that could be placed at point **X**, which is directly above the centre of the rear axle **A**, as shown in the diagram above.

answer = ____________________ N

(2)

(Total 12 marks)

17 (a) Define the moment of a force.

____

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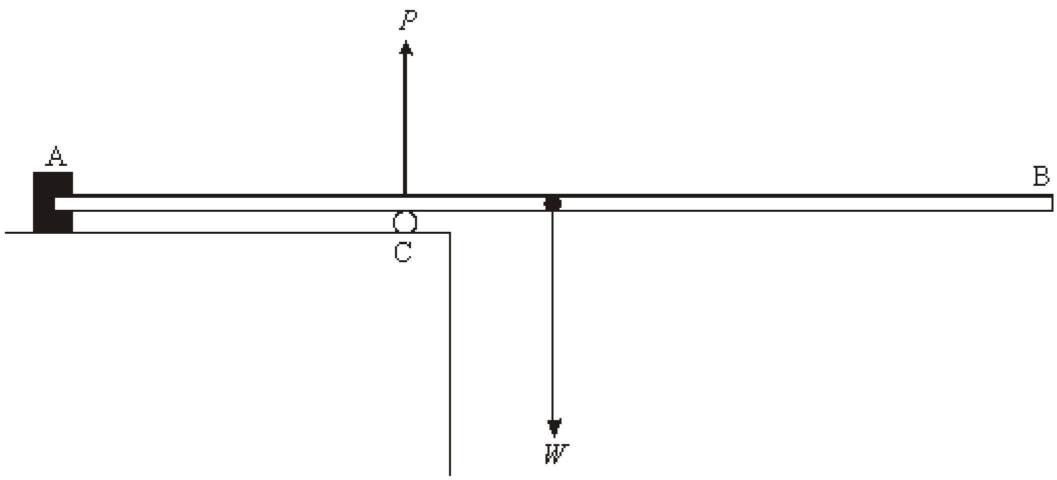
(2)

(b) The diagram shows a uniform diving board of weight, *W*, that is fixed at A. The diving board is supported by a cylinder at C, that exerts an upward force, *P*, on the board.



(i) By considering moments about A, explain why the force *P* must be greater than the weight of the board, *W*.

____

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____

(ii) State and explain what would be the effect on the force *P* of a girl walking along the board from A to B.

____

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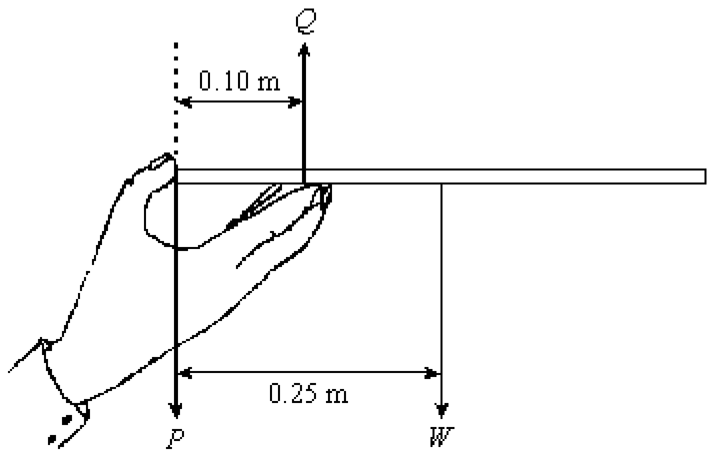
(4)
(Total 6 marks)

18 A waiter holds a tray horizontally in one hand between fingers and thumb as shown in the diagram.



P, *Q* and *W* are the three forces acting on the tray.

(a) (i) State **two** relationships between the forces that must be satisfied if the tray is to remain horizontal and in equilibrium.

___

___

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(ii) If the mass of the tray is 0.12 kg, calculate the magnitude of the force *W*.

___

___

___

(iii) Calculate the magnitudes of forces *P* and *Q*.

___

___

___

___

(6)

(b) The waiter places a glass on the tray. State and explain where the glass should be positioned on the tray if the force, *P*, is to have the same value as in part (a).

(2)

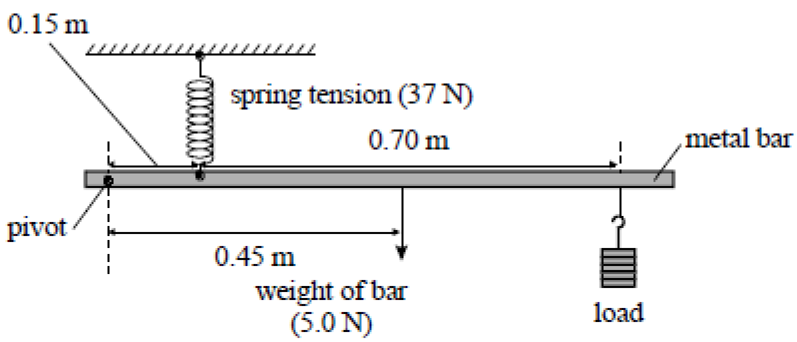
(Total 8 marks)

19 (a) State the *principle of moments*.

(3)

(b) To increase the extension of a stiff spring for a given load, a student set up the system shown in the diagram. The weight of the metal bar was 5.0 N and the tension the student achieved in the spring was 37 N.

the gravitational field strength, g = 9.8 N kg^{-1}



(i) Apply the principle of moments to calculate the mass of the load that the student used.

(4)

(ii) Calculate the magnitude of the force exerted on the metal bar at the pivot.

(1)

(iii) Draw on an arrow on the diagram to show the direction of the force calculated in part (ii).

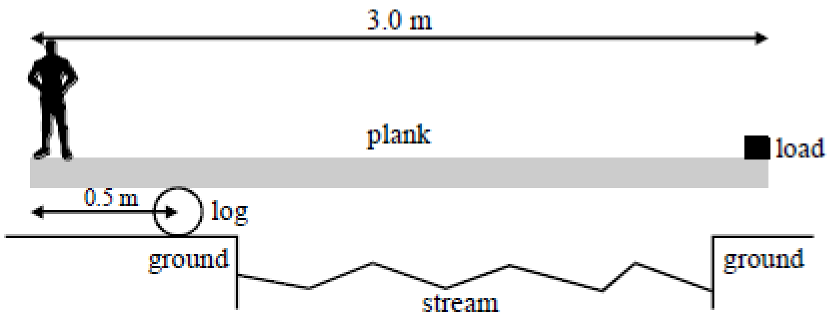
(1)

(c) The spring stiffness k of the spring was 550 N m^{-1}. Calculate the energy stored in the spring.

(2)

(Total 11 marks)

20 The diagram below shows a student standing on a plank that pivots on a log. The student intends to cross the stream.



(a) The plank has a mass of 25 kg and is 3.0 m long with a uniform cross-section. The log pivot is 0.50 m from the end of the plank. The student has a mass of 65 kg and stands at the end of the plank. A load is placed on the far end in order to balance the plank horizontally.

Draw on the diagram the forces that act on the plank.

(3)

(b) By taking moments about the log pivot, calculate the load, in N, needed on the right-hand end of the plank in order to balance the plank horizontally.

Gravitational field strength, $g = 9.8\ \text{N kg}^{-1}$

Load ____________________

(3)

(c) Explain why the load will eventually touch the ground as the student walks towards the log.

____

____

____

____

(2)

(Total 8 marks)

Mark schemes

1 (a) a (resultant) force directed through the centre of mass of an object will not give it a moment / will not cause the object to rotate owtte
or all the mass of the object appears to be concentrated at the centre of mass owtte
or point at which all the (object's) weight acts ✓ owtte

We are not distinguishing between c of g and c of m. So allow point at which all the mass acts.

If a balance idea is given the situation described must be achievable.

Don't allow answers like:

Where mass is most concentrated It has the same mass on both sides All forces act through this point

1

(b) (moment of plank from the bank = *mg* × *d*) = 32 × 9.81 × 2.0 or 32 × g × 2.0 ✓
this moment is balanced by *F* × 3.2 giving *F* = 200 (N) ✓ (196 N)

Award 2 marks if 196 (N) is seen but 200 (N) only gains 1 mark with the second mark available if working is shown

9.8m s^2 is ok for g.

2

(c) (At the point of tipping) there is no (reaction) force from the bank ✓ (This point must be in words not implied from a calculation)
Taking moments about the rock
LHS = 1.2 × 32 × *g* = 38.4 × *g* = 380 (Nm) ✓ (377 N m)
RHS = 0.80 × 46 × *g* = 36.8 × *g* = 360 (Nm) ✓ (361 N m)
Or show a moment calculation that gives the maximum boy's weight that can be supported (471 N)
Or show a moment calculation that gives the maximum distance the boy can be from the rock without tipping (0.83 m) Score any two of the above marks
(Therefore) plank will not tilt ✓ (to score this mark the answer must be justified)

NB the first 3 marking points score a maximum of 2 marks.

The last mark makes up the total to 3 marks

Note it is the RHS mark that has the alternative approaches

Condone missing 'g' provided it is cancelled / missed out in both moment calulations.

The last mark can come from an ecf as long as the reason is clearly stated in terms of the answers given earlier

3

[6]

2 (a) sum of clockwise moments equals sum of anticlockwise moments **(1)**
for a body in equilibrium **(1)**

2

(b) point in the body through which the weight / mass (appears to) acts
[or point where resultant torque / moment is zero]
[or point where body would balance] **(1)**

1

(c) (i) towards A **(1)**
so that weight of ruler **(1)**
provides balancing moment **(1)**

(ii) (moments about pivot give) 1.0 × (0.30 – d) = 0.50 × d **(1)**
1.5 d = 0.30 and d = 0.20 m **(1)**

5

[8]

3 (a) Use of moment formula

C1

0.5 × 550 + 1.2 × 650 = Weight C × 2.1

C1

Weight C = 502 N

A1

(b) Weight of see-saw = 9.8 × 35 = 343 N **or** total people wt = 1200 + C ecf

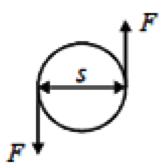
B1

Total weight = 2.05 kN

B1

[5]

4 (a) (i)



two forces opposing **(1)**
forces parallel **(1)**
s correct **(1)**

(ii) N m **(1)**

(4)

(b) (i) anticlockwise moments = clockwise moments **(1)**

(ii) weight of beam acts at centre **(1)**
this is through the pivot **(1)**

(3)

(c) (equating moments gives) 400 × 1.0 = 200 × 0.50 + 250 × d **(1)**
∴ 400 – 100 = 250 × d and d = 1.2 m **(1)**

(2)

[9]

5 (a) for equilibrium**(1)**
clockwise moment = counterclockwise moment (1)

(2)

(b) (i) right hand support

W_p = 88 (N) and W_x = 29 (N) **(1)**

F = 44 + 29 = 73 N **(1)**

left hand support

F = 44 N **(1)**

(ii) right hand support, moments about left hand support

88 × 0.75 + 29 × 0.5 = F × 1.5 gives F = 54 N **(1)**

left hand support

$F_L + F_R$ = 118 (N) **(1)** so F_L = 64 N **(1)**

(6)

[8]

6 (a) force × distance

B1

perpendicular distance (from force) to pivot

B1

(2)

(b) (i) both string tension directions labelled and correct

B1

both weight force directions labelled and correct;

B1

(2)

(ii) statement or use of sum of moments = zero

B1

5 × 0.15 + 10 × 0.25 = T_A × 0.5
T_A = 2(0.75 + 2.5) = 3.25 × 2 = 6.5 N

A1

(3)

(iii) T_B = 15 – 6.5 = 8.5 N (e.c.f.)

A1

(1)

[8]

7 (a) vague statement:
e.g. clockwise moments = anticlockwise moments
or recognition of the equilibrium condition
precise statement: must have 'sum of' and equilibrium condition
i.e. when in equilibrium sum of clockwise moments =
sum of anticlockwise moments (about any point)

C1

or Σclockwise moments = Σanticlockwise moments

or vector sum of moments = 0

or no resultant moment (or torque)

A1

(2)

(b) (i) correct moments equation (354 N seen)

C1

175 N to 180 N (177 N)

A1

(2)

(ii) 95 N to 100 N (98 N)

or 275 – (i)

or 550 – 354 = 196 N

(i.e. e.c.f. for those who forget about two hands and feet;

also allow reverse answers as e.c.f.)

A1

(1)

(c) (i) two friction forces correctly shown at ground level

(at least one on the line)

B1

(1)

(ii) friction between the hands and the floor
or resistance to relative motion of hands and floor

B1

(1)

(iii) 420 N

B1

(1)

[8]

8 (a) (i) 1.05 (1.1) N m (up for J)

B1 **1**

(ii) 0.70 N m (condone 1 sf)

B1 **1**

(iii) weight of bar = 1.59 N (1.8 if (a) (i) = 1.1)

B1 **1**

(b) (i) 3.4 N (3.2 N if weight = 1.8 N) {ecf 5 – (a) (iii)}

B1 **1**

(ii) upwards (not clockwise)
(allow ecf for answer consistent with weight
i.e. down if (weight +2)>7)

B1 **1**

[5]

9 (a) use of $mg = k\Delta l$ (or $0.90 \times 9.81 = 60\Delta l$)**(1)**
Δl = 0.15 m **(1)**

(2)

(b) no tipping if moment of weight of clamp about A > moment of 0.90 kg **(1)**
moment of 0.90 kg about A = 0.90 g × 0.18 = 0.16 g
moment of weight of clamp about A = 1.60 g × 0.12 = 0.19 g
∴ no tipping **(1)**

(2)

(c) as mass vibrates tension changes **(1)**
maximum tension increases as amplitude increases because maximum length increases **(1)**
tipping when moment of tension exceeds moment of weight of clamp **(1)**

(3)

[7]

10 (a) (moment =) Force x <u>perpendicular</u> distance ✓
<u>between line of action</u> (of force) <u>and pivot / point</u> ✓

both marks need to be clear − avoid bod
if the force is named specifically (e.g. weight) mark the work but give a maximum of 1 mark
ignore extra material such as law of moments

2

(b) (i) moment = 250 × 0.048 = 12 ✓ (allow 12000 for this mark)

only allow answers in other units if consistent e.g. 1200 N cm

N m ✓ (stand alone mark if no number is present but only for N mm, N cm and N m)

no working shown can gain full marks if answer and unit are consistent
newton should be upper case if a symbol and metre should be in lower case (but only penalise if it is very obviously wrong)

2

(ii) *Y* × 0.027 = 12 OR Y = 12 / 0.027 ✓
(allow use of 12 and 27 for this mark)
= 440 (N) ✓ (444.4 N) CE from (i)

Y = (i) / 0.027

treat power of 10 error as an AE

note 450 N is wrong

1 sig fig is not acceptable

2

(iii) *(k = F / ΔL)*
= 444.4 / 0.015 ✓ CE from (ii)
= 3.0×10^4 (Nm^{-1}) ✓ (29630 Nm^{-1})

k = (ii) / 0.015

treat power of 10 error as an AE

using 440 gives 2.9×10^4 (Nm^{-1})

1 sig fig is not acceptable

2

(iv) *W* (= ½ *F ΔL*) = ½ × 444.4 × 0.015
Or
W (= ½ *k* ΔL^2) = ½ × 29630 × 0.015^2 ✓
(give this mark for seeing the digits only ie ignore powers of 10 and allow CE from (ii) or (iii) as appropriate
= 3.3 (J) ✓ (3.333 J)

W = ½ × (ii) × 0.015

W = ½ × (iii) × 0.015^2

treat power of 10 error as an AE

if either equation misses out the ½ no marks

common CE is to use F = 250 N which can be used giving W = 1.9 J

2

[10]

11 (a) (sum of) clockwise moment(s) = (sum of) anticlockwise moment(s) ✓
sum of clockwise moment **s** = **sum of** anticlockwise moment **s** (about any given point) ✓
(for a system in) equilibrium ✓ allow 'balanced'

third mark depends upon the first
Don't allow references to 'forces' being balanced.
Don't allow 'stationary'.
Allow 'total', etc instead of sum
Ignore definitions of moment

3

(b) (i) 35 × 110 (×10^{-3}) ✓
(= 3.85) = 3.9 (or 3.8) ✓

allow 4 or 3.90 but not 4.0

(3.9) **Nm** / allow (3850, 3900) **Nmm** ✓ don't allow nm, NM

unit must match answer

3

(ii) 3.85 = T × 25 (×10^{-3}) ✓ ecf from (bi)

Correct answer with no working gets 2 out of three.

T = 3.85 / 25 (×10^{-3}) = 0.150 (×10^{3}) ✓ ecf

Allow 156 (160) N from rounding error

= 150 (154 N) ✓

3

(c) *(P = Fv , F = P / v)*
= 2.8(× 10^{3}) / 15 ✓
= 190 (186.7 N) ✓

2

[11]

12 (a) (i) (moment = 520 x 0.26) = 140 (135.2) ✓

Nm ✓

2

(ii) **180 x 0.41** and **0.63 X** seen ✓

135.2 = 180 x 0.41 + 0.63 X ✓ ecf from (a)(i)

(X = (135.2 – 73.8) / 0.63)

= 97 ✓ (N) (97.46) allow 105 from use of 140Nm ecf from (a)(i)

3

(iii) (520 – (180 + 97.46))

= 240 ✓ (242.5 N) ecf (or from correct moments calculation)

1

(b) (i) ($v^2 = u^2 + 2as$)

9.3^2 = 2 x a x 35 OR 9.3^2=70a OR a = $v^2/2s$
OR $9.3^2/70$ ✓

OR correct alternative approach

1.2 (1.2356) ✓ (m s^{-2})

2

(ii) ($m = W/g$) = 520/9.81 (= 53.0) ✓ (kg)

$F = ma$ = 53 × 3bi (1.2356) = 65 (N) (65.49) ✓

accept use of 1.2 giving 64(63.6) , allow 53 x 124 = 65.7

2

[10]

13 (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 ✓

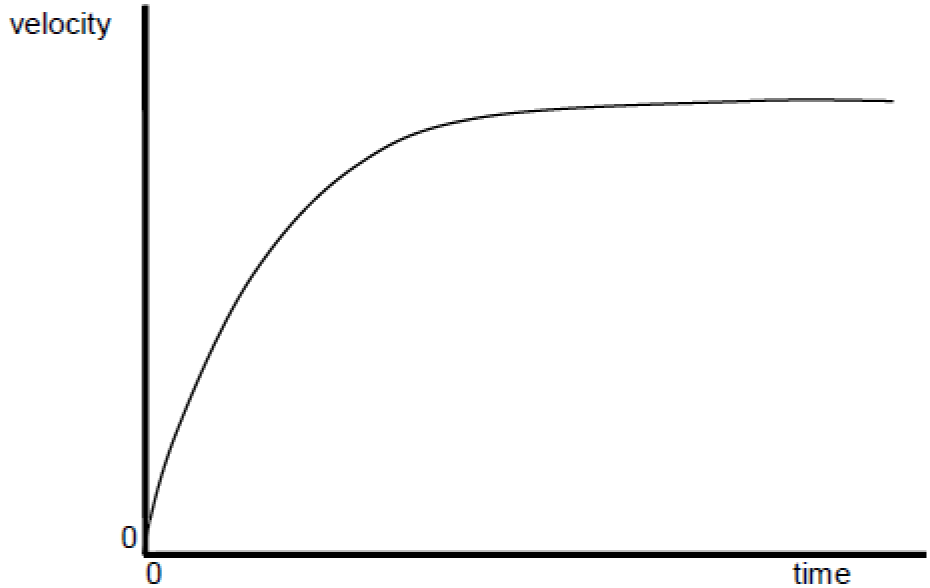
correctly linked to its effect on air resistance/drag ✓

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]

14 (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]

15 (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]

16 (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 × 1.4 = F × 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 =) $\frac{(a)(iii)}{100000}$ **(1)**

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

2

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

F = (2 × 6500) = 13000 (N) **(1)**

2

[12]

17 (a) product of the force and the **perpendicular distance (1)**
reference to a point/pivot **(1)**

2

(b) (i) since *W* is at a greater distance from A **(1)**
then *W* must be less than *P* if moments are to be equal **(1)**

(ii) *P* must increase **(1)**
since moment of girl's weight increases as she moves from A to B **(1)**
correct statement about how P changes
(e.g. P minimum at A, maximum at B, or P increases in a
linear fashion) **(1)**

max 4

[6]

18 (a) (i) resultant force acting on tray is zero [or *P* + *W* = *Q*] **(1)**
resultant torque is zero
[or correct moments equation
or anticlockwise moments = clockwise moments] **(1)**

(ii) *W*= 0.12 × 9.81 = 1.2N **(1)** (1.18N)

(iii) (taking moments about P gives)
$Q \times 0.1 = 0.12 \times 9.81 \times 0.25$ **(1)**
$Q = 2.9$ N (2.94 N) **(1)**
$P = 2.9 – 1.2 = 1.7$ N **(1)** (or 2.94 – 1.18 = 1.76 N)
(allow C.E. for values of *W* and *Q)*

6

(b) placed at Q **(1)**
no additional turning moment about Q **(1)**

2

[8]

19 (a) when in equilibrium **B1**

clockwise moments = anticlockwise moments **C1**

(i.e. a superficial response)
sum (or Σ) of the clockwise moments = sum of the anticlockwise moments
or no resultant moment or torque **A1**

(3)

(b) (i) attempt to take moments with an omission or a distance error **C1**

correct moments equation **C1**

3.9 N (condone s.f. if they go no further) **B1**

0.40 kg **B1**

allow this for their force / 9.8

(4)

(ii) 28 N (37– 5– their (i)) **B1**

(1)

(iii) arrow shown downwards **B1**

(1)

(c) extension = 37 / 550 = 0.067 m
or use of $0.5\, F^2 / k$ **or** $\frac{1}{2}\, k\, (\Delta l)^2$ **and** $k = F / (\Delta l)$ **C1**

allow 1 for $\frac{1}{2}\, F\, \Delta l = \frac{1}{2}\, k\, (\Delta l)^2$
1.24 J (c.n.a.o) **A1**

(2)

[11]

20 (a) wt of person + load marked vertically downwards **B1**

wt of plank marked in centre downwards **B1**

upward force at pivot marked
inappropriate reaction forces loses one mark **B1**

(b) clear attempt to equate moments in both senses **C1**

$65g \times 0.5 = 25g \times 1.0 + L \times 2.5$ **C1**

$L = 29.4$ [N] **A1**

(c) anticlockwise / student moment becomes smaller **B1**

clockwise moment now larger or plank rotates clockwise **B1**

[8]