The following list of formulae may be found useful :

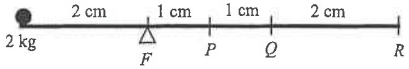
Moment of a force — moment $= F \times d$

Use the following data wherever necessary :

Acceleration due to gravity — $g = 9.81\ \text{m s}^{-2}$ (close to the Earth)

Part A : HKCE examination questions

1. < HKCE 1987 Paper II - 9 >

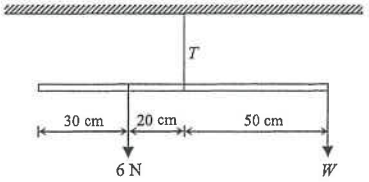


If a mass of 2 kg is placed at a distance of 2 cm from the fulcrum F as shown in the diagram, which of the following cases could keep the light rod in equilibrium ?

(1) a mass of 4 kg placed at P
(2) a mass of 2 kg placed at Q
(3) a mass of 1 kg placed at R

A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

2. < HKCE 1990 Paper II - 9 >

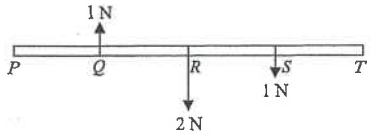


In the figure shown, the uniform metre rule of weight 1 N is balanced horizontally. Find the tension T in the string.

A. 2.4 N
B. 3.4 N
C. 8.4 N
D. 9.4 N

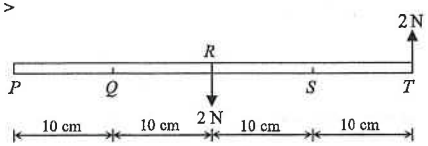
3. < HKCE 1992 Paper II - 11 >

The diagram shows a light rod under the action of three vertical forces. The points P, Q, R, S and T are equally spaced along the rod. At which point must an upward vertical force of 2 N be applied to hold the rod in equilibrium ?



A. P
B. Q
C. R
D. S

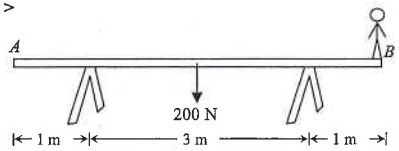
4. **< HKCE 1994 Paper II - 7 >**



The above diagram shows a light rod under the action of two vertical forces. Under which of the following conditions will the rod be in equilibrium ?

A. Applying an upward force of 2 N at *P*.
B. Applying a downward force of 2 N at *P*.
C. Applying an upward force of 4 N at *R* and a downward force of 4 N at *Q*.
D. Applying an upward force of 4 N at *Q* and a downward force of 4 N at *R*.

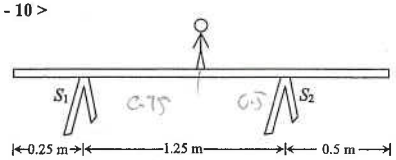
5. **< HKCE 1996 Paper II - 9 >**



A uniform plank *AB* of weight 200 N rests on two trestles as shown above. A boy stands at the end *B* of the plank. What can the maximum weight of the boy be without tilting the plank ? (Assume the weight of the plank acts through its centre.)

A. 75 N
B. 100 N
C. 200 N
D. 300 N

6. **< HKCE 1997 Paper II - 10 >**



A light plank of length 2 m rests on two trestles S_1 and S_2 as shown in the figure. A boy of weight 500 N stands at the mid-point of the plank. Find the forces acting on the two trestles by the plank.

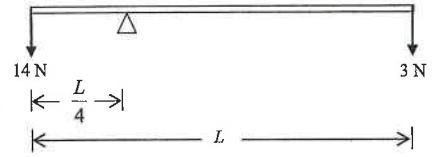
	Force acting on S_1	**Force acting on S_2**
A.	$166\frac{2}{3}$ N	$333\frac{1}{3}$ N
B.	200 N	300 N
C.	250 N	250 N
D.	300 N	200 N

7. **< HKCE 1998 Paper II - 11 >**

A uniform beam of length 3 m and weight 300 N lies on a horizontal ground. What minimum vertical force must be applied to one end of the beam to just lift that end off the ground ? (Assume the weight of the beam acts through its mid-point.)

A. 100 N
B. 150 N
C. 300 N
D. 450 N

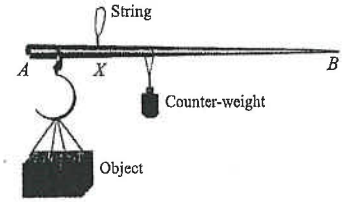
8. **< HKCE 1999 Paper II - 9 >**



A uniform rod of length L is pivoted at a point $\frac{1}{4}L$ from one of its ends. Two forces 14 N and 3 N act on its two ends as shown above. If the rod is in equilibrium, find the weight of the rod.
(Assume the weight of the rod acts through its midpoint.)

A. 2.5 N
B. 5 N
C. 8 N
D. 11 N

9. **< HKCE 2000 Paper II - 12 >**

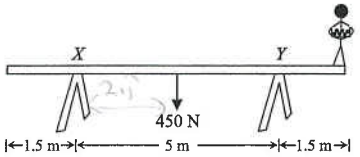


A company intends to produce a kind of weighing device as shown. The device is held at point *X*. The position of the counter-weight is adjusted until the rod *AB* becomes horizontal. The weight of the object can be read from the scale calibrated on *AB*. Which of the following changes can increase the maximum weight that can be measured by the device ?

(1) moving the string at *X* towards *A*
(2) increasing the mass of the counter-weight
(3) increasing the length of the string from which the counter-weight hangs

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

10. **< HKCE 2001 Paper II - 6 >**



A uniform plane of weight 450 N rests on two trestles *X* and *Y* and a worker of weight 675 N stands at one end of the plank as shown above. The worker holds a light basket which contains several packets of goods each of weight 6 N. What is the maximum number of packets he can hold without tilting the plank ?

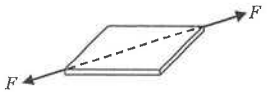
A. 11
B. 12
C. 13
D. 18

11. **< HKCE 2002 Paper II - 11 >**

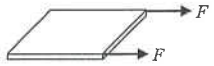
A block is initially at rest on smooth horizontal ground. Two forces of equal magnitude F act on the block. In which of the below cases will the block remain at rest ?

(1)

(2)

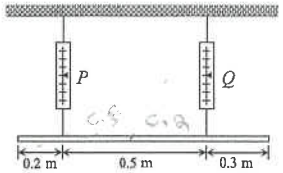


(3)



A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

12. **< HKCE 2003 Paper II - 10 >**



A uniform rod of weight 50 N is supported by two spring balances P and Q and remains at rest as shown above. Assume the weight of the rod acts through its mid-point. Find the readings of P and Q.

	Reading of P	Reading of Q
A.	17 N	33 N
B.	20 N	30 N
C.	30 N	20 N
D.	33 N	17 N

13. **< HKCE 2004 Paper II - 11 >**

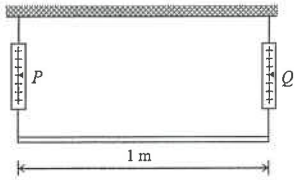


Figure (a)

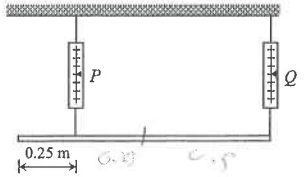


Figure (b)

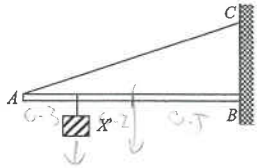
Figure (a) shows a uniform plank supported by two spring balances P and Q. The readings of the two balances are both 150 N. P is now moved 0.25 m towards Q (see Figure (b)). Find the new readings of P and Q.

	Reading of P / N	Reading of Q / N
A.	100 N	200 N
B.	150 N	150 N
C.	200 N	100 N
D.	200 N	150 N

Part B : HKAL examination questions

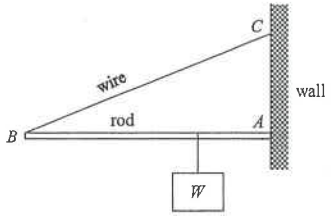
14. **< HKAL 1994 Paper IIA - 3 >**

A uniform metre rule AB of mass 0.15 kg is hinged to a wall at B and the other end A is connected by a wire attached to the wall at C as shown in the figure. A block X of mass 0.1 kg is hung from the metre rule at 30 cm from A. The metre rule is horizontal. Find the moment of the tension in the wire about B.



A. 1.42 N m
B. 1.05 N m
C. 0.75 N m
D. 0.70 N m

15. **< HKAL 1995 Paper IIA - 8 >**

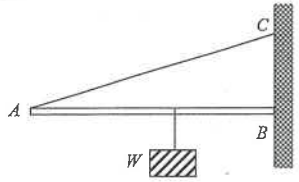


The figure shows a uniform rod AB being held in horizontal position by a wire attached to a wall at point C with the other end pivoted at A. The rod carries a load W. If W is shifted gradually from A towards B, which of the following quantities will increase ?

(1) moment of the weight of the rod about A
(2) moment of the load W about A
(3) tension of the wire

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

16. **< HKAL 2000 Paper IIA - 3 >**



A light rigid rod AB is hinged to the wall at one end while the other end is connected by an inextensible string to a point C vertically above B. A weight W is suspended from a point on the rod. If the rod remains horizontal, which of the following change(s) would increase the tension in the string ?

(1) Shifting the weight towards A.
(2) Replacing the string with a shorter one and connecting it to the mid-points of AB and BC.
(3) Replacing the string with a longer one and connecting it to a point higher than C.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Part C : HKDSE examination questions

17. < HKDSE Sample Paper IA - 10 >

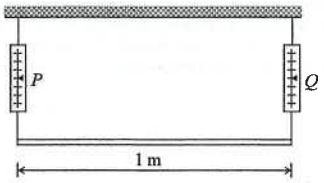


Figure (a)

Figure (a) shows a uniform plank supported by two spring balances P and Q. The readings of the two balances are both 150 N.

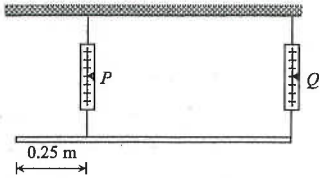


Figure (b)

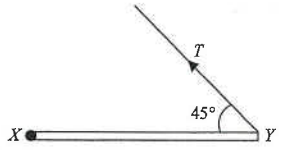
P is now moved 0.25 m towards Q as shown in Figure (b). Find the new readings of P and Q.

	Reading of P / N	Reading of Q / N
A.	100 N	200 N
B.	150 N	150 N
C.	200 N	100 N
D.	200 N	150 N

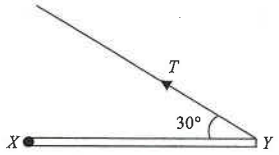
18. < HKDSE Practice Paper IA - 12 >

A rod XY hinged at X is kept horizontal by a light string. M is the midpoint of XY. In which of the following arrangements will the tension T in the string be the smallest ?

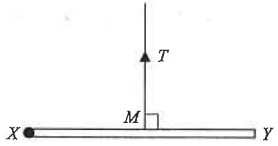
A.



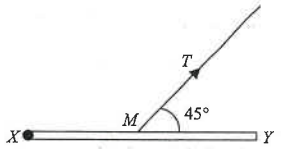
B.



C.

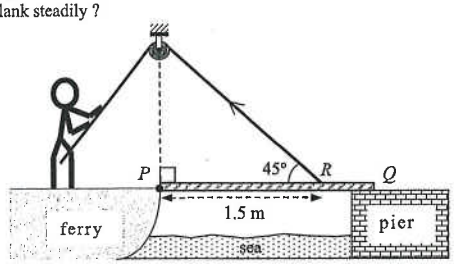


D.



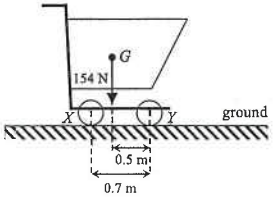
19. < HKDSE 2012 Paper IA - 6 >

A uniform gangplank PQ of a ferry smoothly hinged at end P initially rests horizontally on the pier. The gangplank has mass M and length 2 m. It is raised by a man on the ferry using a light rope passing a smooth fixed light pulley and connecting to R on the gangplank as shown. R is 1.5 m from end P. Which of the following correctly describes the force required to raise the gangplank steadily ?



	initial force required to raise the gangplank when it is horizontal	*subsequent* force required to raise the gangplank
A.	0.67 Mg	greater than 0.67 Mg
B.	0.67 Mg	smaller than 0.67 Mg
C.	0.94 Mg	greater than 0.94 Mg
D.	0.94 Mg	smaller than 0.94 Mg

20. < HKDSE 2013 Paper IA - 9 >



The figure shows a supermarket trolley resting on the ground. The separation between cylindrical wheels X and Y is 0.7 m. When the trolley is loaded to a total weight of 154 N, its centre of gravity G is at a horizontal distance of 0.5 m from the wheel Y. What is the reaction acting on the wheel X from the ground ?

A. 44 N
B. 62 N
C. 92 N
D. 110 N

21. < HKDSE 2013 Paper IA - 14 >

A semi-circular cardboard hangs from a spring balance from point O as shown. The reading of the spring balance is 5 N. Which statements are correct ?

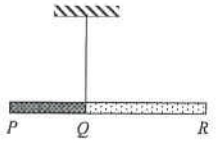
(1) The weight of the cardboard is 5 N.

(2) The centre of gravity of the cardboard is directly under O.

(3) The reading of the balance becomes zero if the set-up is brought to the Moon's surface.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

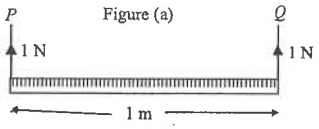
22. **< HKDSE 2014 Paper IA - 3 >**

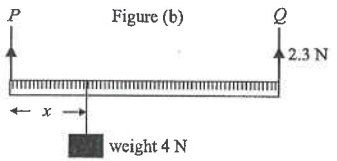


PQR is a composite rod having a uniform cross-section but with portions PQ and QR made of different materials, each of uniform density. The ratio of the length of PQ to that of QR is 2 : 3. When the rod is suspended at Q, it remains horizontal as shown. What is the ratio of the mass of PQ to that of QR ?

A. 2 : 3
B. 1 : 1
C. 3 : 2
D. Answer cannot be found as the ratio of their densities is not given.

23. **< HKDSE 2016 Paper IA - 11 >**



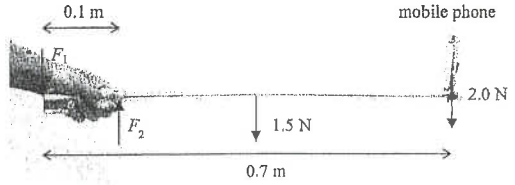


A uniform metre rule is supported by vertical wires P and Q and remains at rest horizontally as shown in Figure (a). The tension in each wire is 1 N. When a weight of 4 N is hung from the metre rule at a certain position as shown in Figure (b), the tension in Q becomes 2.3 N while the metre rule remains horizontal. Find the distance x shown.

A. 32.5 cm
B. 57.5 cm
C. 67.5 cm
D. Answer cannot be found as the tension in P is not known.

24. **< HKDSE 2017 Paper IA - 8 >**

Selfie sticks are popular nowadays. A uniform selfie stick of length 0.7 m is held horizontally as shown. Assume that the forces required to hold the selfie stick by the hand are represented by F_1 and F_2 , and F_1 and F_2 are perpendicular to the stick.



It is given that the weight of the selfie stick and the mobile phone are 1.5 N and 2.0 N respectively. Taking the mobile phone as a point mass, estimate the magnitude of F_2 .

A. 3.5 N
B. 19.3 N
C. 35 N
D. Cannot be determined as F_1 is unknown.

1.5 × 0.35 + 2 × 0.1 = F_2 · 0.1

There is question in next page

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1.	D	6.	B	11.	A	16.	C	21.	A	26.	D
2.	D	7.	B	12.	B	17.	C	22.	C		
3.	D	8.	B	13.	C	18.	A	23.	A		
4.	D	9.	C	14.	A	19.	D	24.	B		
5.	D	10.	B	15.	D	20.	D	25.	B		

M.C. Solution

1. D

Moment of 2 kg mass about $F = 2 \times 2 = 4$

✓ (1) Moment of 4 kg mass about $F = 4 \times 1 = 4$ = Moment of given mass about F

✓ (2) Moment of 2 kg mass about $F = 2 \times 2 = 4$ = Moment of given mass about F

✓ (3) Moment of 1 kg mass about $F = 1 \times 4 = 4$ = Moment of given mass about F

2. D

Note that the weight of the metre rule 1 N is at the mid-point of the rule.

Take moment about right end, the force W does not have moment.

$\therefore$ $(6) \times (20 + 50) + (1) \times (50) = T \times (50)$

$\therefore$ $T = 9.4$ N

3. D

Moment of the couple at Q and $S = 1 \times 2 = 2$ (clockwise)

To balance this couple, another couple in anticlockwise direction is needed.

Moment of the other couple = $(2) \times d = 2$ $\therefore$ $d = 1$

An upward force of 2 N applied at point S can then give another couple to make the rod in equilibrium.

4. D

Moment of the given couple = $2 \times 2 \times 10 = 40$ N cm

Moment of the required couple = Moment of the given couple

$\therefore$ $4 \times d = 40$ $\therefore$ $d = 10$ cm

Given couple is in anti-clockwise direction $\Rightarrow$ the required couple is clockwise

$\therefore$ The required points should have a separation of 10 cm, and in clockwise direction. Only D can satisfy this.

5. D

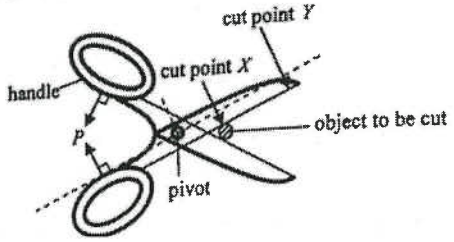
Take moment about right trestle,

$(200) \times (1.5) = W(1)$ $\therefore$ $W = 300$ N

25.<HKDSE 2019 Paper IA-7>

26. <HKDSE 2020 Paper IA-7>

The figure shows that a pair of forces P of constant magnitude is applied at right angles to the handles of a pair of scissors in order to cut an object.



6. B

Take moment about S_2,

$F_1 \times (1.25) = (500) \times (1 - 0.5)$ $\therefore$ $F_1 = 200$ N

Balance of forces,

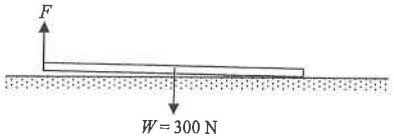
$(200) + F_2 = 500$ $\therefore$ $F_2 = 300$ N

7. B

Take moment about the other end,

$F \times (3) = (300) \times (1.5)$

$\therefore$ $F = 150$ N



8. B

Take moment about the pivot,

$14 \times \frac{L}{4} = W \times \frac{L}{4} + 3 \times \frac{3L}{4}$ $\therefore$ $W = 5$ N

9. C

Take moment about X, $W_o d_o = W_w d_w$.

✓ (1) Moving the string towards $A \Rightarrow d_o \downarrow$ $\therefore$ $d_w \uparrow$ $\therefore$ $W_o \uparrow$

✓ (2) $W_w \uparrow \Rightarrow W_o \uparrow$

× (3) The length of the string hanging the counter-weight has no effect on W_w and d_w

10. B

Let the maximum number of packets he can hold be n.

When he holds the maximum packets, the plank will just tilt so that X will lose contact with the plank.

Take moment about Y,

$450 \times 2.5 = (675 + 6n) \times 1.5$ $\therefore$ $n = 12.5$

$\therefore$ The maximum number of packets is 12 without tilting the plank.

11. A

× (1) The two forces form a couple and cause the block to rotate, thus the block will not remain at rest.

✓ (2) The two forces will balance each other, so there is no net force acting on the block, the block will remain at rest.

× (3) The two forces give a resultant force towards the right causing an acceleration towards the right, thus the block will not remain at rest.

12. B

Take moment at the point under balance P: $50 \times 0.3 = Q \times 0.5$ $\therefore$ $Q = 30$ N

Balance of forces : $P + 30 = 50$ $\therefore$ $P = 20$ N

13. C

Weight of the plank = 150 + 150 = 300 N

In Figure (b), take moment about the point under balance Q:

$P \times (1 - 0.25) = 300 \times 0.5$ $\therefore$ $P = 200$ N

Balance of forces : $200 + Q = 300$ $\therefore$ $Q = 100$ N

14. A

Take moment about B,

Moment of tension about B = moment of weight of X + moment of weight of metre rule

$= (0.1 \times 9.81)(1 - 0.3) + (0.15 \times 9.81)(0.5) = 1.42$ N m

15. D

× (1) As the position of the C.G. of the rod remains unchanged, the moment of the weight of rod is unchanged.

✓ (2) As the distance of load W from the pivot A increases, the moment of W increases.

✓ (3) As moment of load W increases, the moment of tension must increase for balancing. Thus, the tension of the wire increases.

16. C

Let the length of AB be L and length of WB be d, and θ be the angle between string and rod.

Take moment about B : $T \sin\theta \cdot L = W \cdot d$

✓ (1) Shifting W towards $A \Rightarrow d \uparrow \Rightarrow T \uparrow$

✓ (2) Replace the string $\Rightarrow \theta$: no change and $L \downarrow \Rightarrow T \uparrow$

× (3) Replace the string $\Rightarrow \theta \uparrow \Rightarrow T \downarrow$

17. C

Weight of the plank = 150 + 150 = 300 N

In Figure (b), take moment about the point under balance Q:

$P \times (1 - 0.25) = 300 \times 0.5$ $\therefore$ $P = 200$ N

Balance of forces :

$200 + Q = 300$ $\therefore$ $Q = 100$ N

18. A

Let the length of the rod be L.

A. Take moment about X: $T \sin 45° \times L = mg \times \frac{1}{2} L$ $\therefore$ $T = 0.707\, mg$

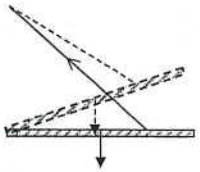
B. Take moment about X: $T \sin 30° \times L = mg \times \frac{1}{2} L$ $\therefore$ $T = mg$

C. Take moment about X: $T \times \frac{1}{2} L = mg \times \frac{1}{2} L$ $\therefore$ $T = mg$

D. Take moment about X: $T \sin 45° \times \frac{1}{2} L = mg \times \frac{1}{2} L$ $\therefore$ $T = 1.41\, mg$

In figure A, the tension is the smallest.

19. D



Initially, take moment about P :

$T \sin\theta \times d = Mg \times \frac{1}{2}L$

$\therefore \quad T \sin 45° \times 1.5 = Mg \times 1 \qquad \therefore \ T = 0.94\,Mg$

Subsequently, when the plank PQ is pulled up,

the C.G. of the plank would be closer to the end P, i.e., the C.G. would be closer than $\frac{1}{2}L$,

$\therefore$ the moment of the weight would decrease, therefore, the tension would decrease.

Note that the angle θ would increase subsequently.

20. D

Take moment about Y.

$R_X \times (0.7) = (154) \times (0.5)$

$\therefore \ R_X = 110$ N

21. A

✓ (1) The reading of the spring balance represents the weight of the supporting body.

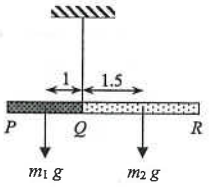
✓ (2) The centre of gravity must be along the line of support.

× (3) On the Moon's surface, the acceleration due to gravity is less than that of the Earth, thus the reading is smaller but not zero.

22. C

Since the cross-section of the rods are uniform,

the centre of weight must be at the middle point of each portion.



Take moment about Q :

$\therefore \ m_1 g \times 1 = m_2 g \times 1.5$

$\therefore \ m_1 : m_2 = 3 : 2$

23. A

In Figure (a), weight of the metre rule is balanced by the tension of P and Q, thus, weight of the metre rule is 2 N.

As the metre rule is uniform, the centre of gravity of the metre rule is at the mid-point, that is, at the 50 cm mark.

In Figure (b), take moment at P.

Moment of Q = moment of the 4 N weight + moment of the weight of the metre rule

$\therefore \ (2.3) \times (100) = (4) \times (x) + (2) \times (50)$

$\therefore \ x = 32.5$ cm

24. B

Take moment at the point of F_1.

$F_2 \times 0.1 = 1.5 \times 0.35 + 2.0 \times 0.7$

$\therefore \ F_2 = 19.25 \approx 19.3$ N

The following list of formulae may be found useful :

Moment of a force — moment $= F \times d$

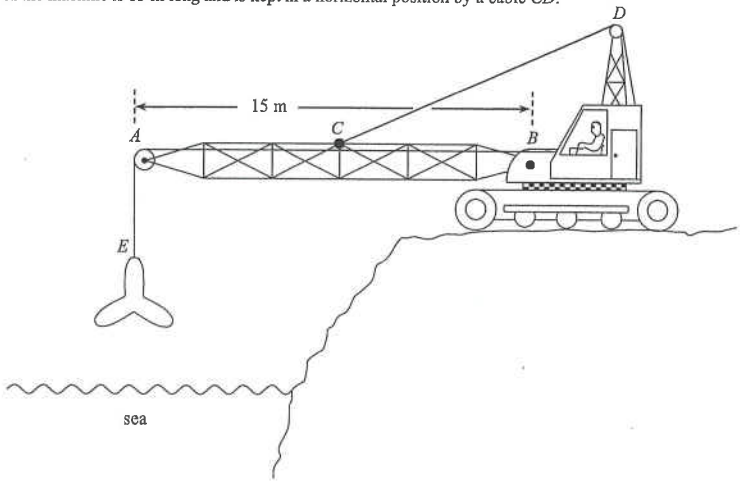
Use the following data wherever necessary :

Acceleration due to gravity — $g = 9.81\ \text{m s}^{-2}$ (close to the Earth)

Part A : HKCE examination questions

1. < HKCE 1986 Paper I - 1 >

A concrete block of total mass 4000 kg is slowly lowered into the sea by a machine as shown in the figure below. The heavy arm AB of the machine is 15 m long and is kept in a horizontal position by a cable CD.



(a) What is the moment of the weight of the concrete block acting about B ? (State whether the moment is clockwise or anticlockwise.) (3 marks)

(b) What other forces acting on the heavy arm AB can also produce moments about B ? (2 marks)

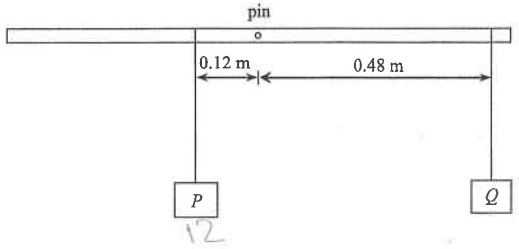
(c) Find the tension in the cable AB if the block is lowered with

(i) uniform velocity of 2 m s^{-1},

(ii) downward uniform acceleration of 2 m s^{-2}. (5 marks)

2. < HKCE 1991 Paper I - 1 >

A uniform metre rule with a small hole bored in the middle is pivoted by a pin inserted into the hole, as shown in the figure below. The weight of the metre rule is 1 N. An object P of weight 12 N is suspended on the left-hand side of the metre rule at a distance of 0.12 m from the pin. Another object Q is also suspended on the right-hand side at a distance of 0.48 m from the pin to balance the metre rule.



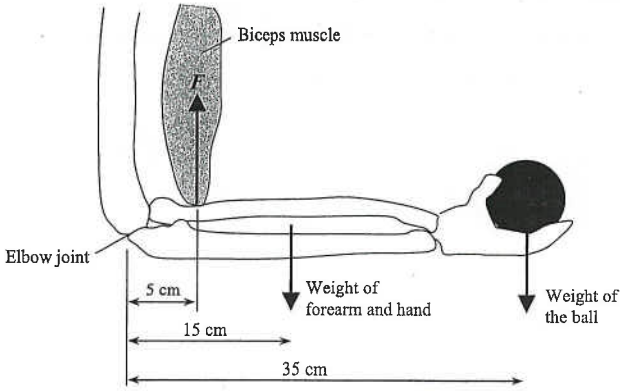
(a) (i) What is the moment of the weight of P about the pin ? (1 mark)

(ii) Find the weight of Q. (2 marks)

(iii) Find the force acting on the metre rule by the pin. (2 marks)

(b) If the metre rule fails to balance before the objects are suspended on it, suggest a simple method to make it balance. (2 marks)

3. < HKCE 2002 Paper I - 3 >



A man holds a ball of weight 60 N with his hand. The weight of the forearm and hand of the man is 20 N, and the biceps muscle in the upper arm exerts an upward force F on the forearm. The horizontal distances of these forces from the elbow joint are shown in the above figure.

(a) Find the moment of the weight of the ball about the elbow joint. (1 mark)

(b) Find the magnitude of F. (2 marks)

(c) Some weight-lifting champions are known to have their biceps muscles a few millimeters further sway from the elbow joint than usual. Explain how this feature can help such athletes in lifting heavy weights. (2 marks)

Part B : HKAL examination questions

4. < HKAL 2009 Paper I - 2 >

A skier bends his back to lift his pair of skis as shown in Figure 1.

Figure 1

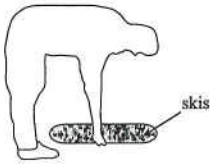


Figure 2 shows the skier's spine as represented by a horizontal light rigid rod OP of length 0.54 m pivoted at the base O. At equilibrium, there are four forces acting on the spine :

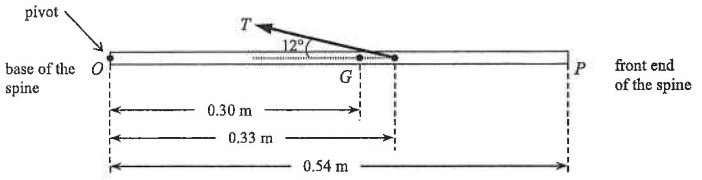
W : the weight of the skier's upper body, which equals 520 N, acting through point G of the spine

L : the load of the pair of skis, which equals 40 N, acting through the front end of the spine P

T : the tension of the back muscle exerting at a point 0.33 m from O, making a angle of 12° with spine

R : the reaction force in the spine acting through the base of the spine O

Figure 2



(a) Calculate the tension T. (2 marks)

(b) Hence explain why it is unhealthy to lift the load in the way shown in Figure 1. (1 mark)

Question Solution

1. (a) Moment $= (4000 \times 9.81) \times 15$ [1]
$= 588\,600$ N m [1]
The moment is anticlockwise [1]

(b) Tension in wire CD [1]
Weight of AB [1]

(c) (i) Tension $= mg = 4000 \times 9.81$ [1]
$= 39240$ N [1]

(ii) $mg - T = ma$ [1]
$\therefore (4000) \times (9.81) - T = (4000) \times (2)$ [1]
$\therefore T = 31240$ N [1]

2. (a) (i) Moment $= 12 \times 0.12$
$= 1.44$ N m [1]

(ii) Take moment about the mid point.
$\therefore (1.44) = Q \times (0.48)$ [1]
$\therefore Q = 3$ N [1]

(iii) Force acting on the pin is upward.
Since forces are balanced in vertical direction,
$\therefore F = 12 + 3 + 1$ [1]
$= 16$ N [1]

(b) Add some plasticine to the lighter side of the rule [1]
until it balances. [1]

3. (a) Moment $= 60 \times 0.35 = 21$ N m [1]

(b) Take moment about the elbow joint,
$\therefore 0.05F = 0.15 \times 20 + 21$ [1]
$\therefore F = 480$ N [1]

(c) If the bicep muscle is further away from the elbow joint, the moment produced by the force F is larger. [1]
So a heavier load can be lifted by the athlete. [1]

4. (a) Take moment about O :
$\therefore (520) \times (0.30) + (40) \times (0.54) = (T \sin 12°) \times (0.33)$ [1]
$\therefore T = 2589$ N <accept 2580 N to 2600 N> [1]

(b) The tension is very large, about 5 times the weight of the body, thus easy to cause injury to the muscle. [1]