2025 Sec 3 Physics Chapter 07 Turning Effect of Forces

Answers to Examples and Exercises

<u>Example 1</u>

(a) The rule has a very small mass and this can be ignored in the calculation.
Other terms: **negligible** mass or **zero** mass.

(b) Moments of F about the pivot = 20 N x (50.0 – 30.0) cm = <u>400 N cm</u> or <u>4.0 Nm</u>.
Direction is <u>anticlockwise</u>.

Exercise 1

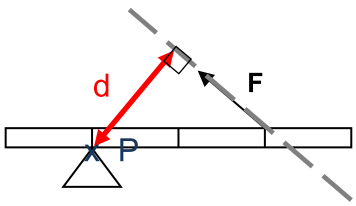
1. When the line of action of the force passes through the pivot.

2. (a) Moment = 6 Nm, Direction = anticlockwise
   (b) Moment = 6 Nm, Direction = clockwise
   (c) Moment = 6 Nm, Direction = anticlockwise
   (d) Moment = 0, Direction = N/A (no turning effect)

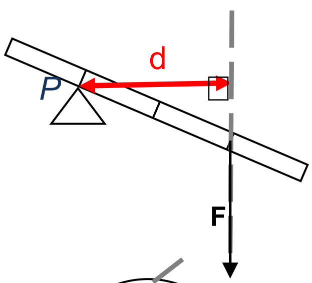
3. (a) All parts of the ruler are similar. (The cross-section & density is the same along its length.)
   The CG of the rule is at its centre and as such, the weight of the ruler acts right through the centre.

   (b) (i) Resultant Moment = 30 Nm, Resultant motion: **rotates** anticlockwise (ii)
   (ii) Resultant Moment = 0 Nm, Resultant motion: remains at rest.
   (iii) Resultant Moment = 0 Nm, Resultant motion: remains at rest.
   (iv) Resultant Moment = 32.5 Nm, Resultant motion: **rotates** anticlockwise
   (v) Resultant Moment = 20 Nm, Resultant motion: **rotates** anticlockwise
   (vi) Resultant Moment = 0.5 Nm, Resultant motion: **rotates** anticlockwise

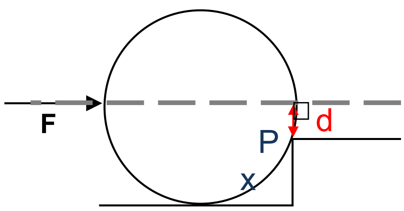
4 (a)



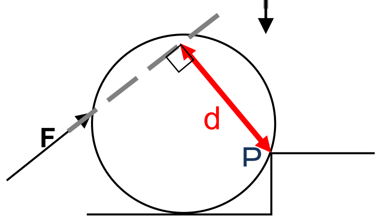
(b)



(c)



(d)



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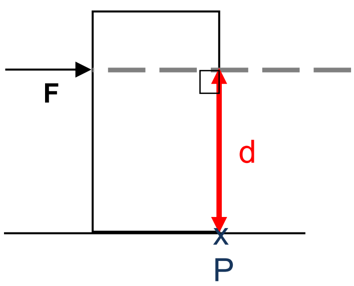

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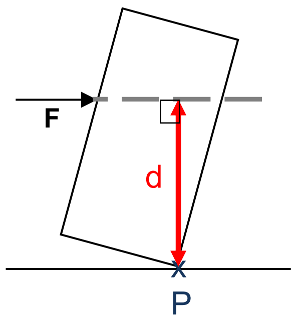
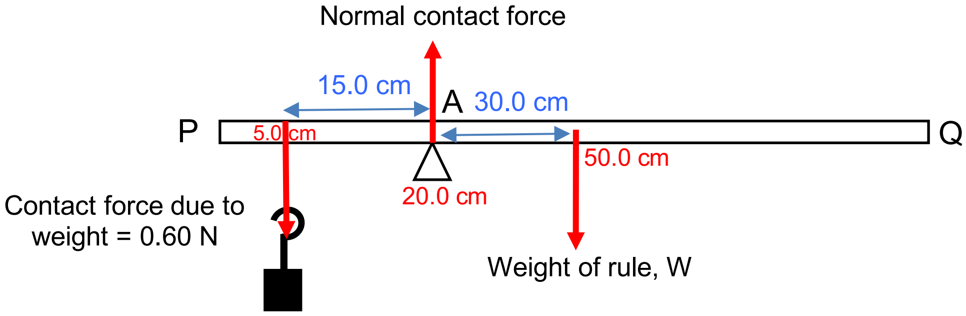


Example 2

(a)



(b) System at equilibrium: apply principle of moments.

Taking moments about A,
clockwise moment = anticlockwise moment about A
W x (50.0 – 20.0) cm = [(60 ÷ 1000) x 10] N x (20.0 – 5.0) cm
W = 0.30 N ∴ Mass of rule = W ÷ 10 = 0.030 kg = 30 g

Example 3

(a) *For a balanced system, clockwise moment = anticlockwise moment about the pivot.*

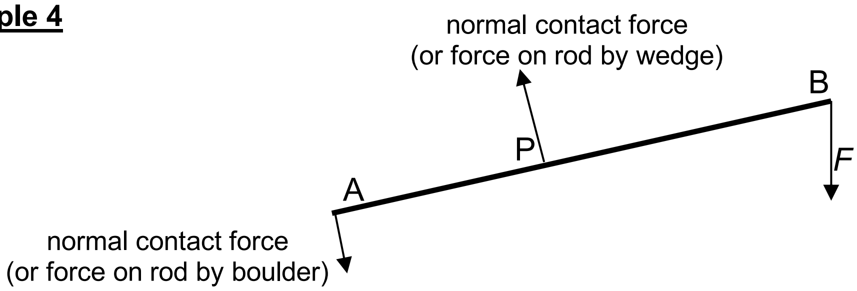
Taking moments about the pivot,
W x (90.0 – 50.0) cm = 24 N x (50.0 – 14.0) cm
W = 21.6 N = 22 N (2 sf)

(b) As the rule is uniform, its CG is at its centre. Thus the line of action of the weight passes through the pivot resulting in zero moment.

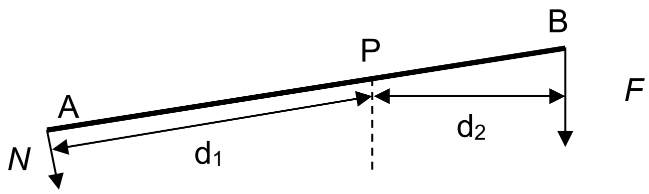
(c) The rule would rotate anticlockwise about the pivot. The anticlockwise moment caused by the 40 N mass is larger than the clockwise moment caused by **W.**

Example 4

(a)



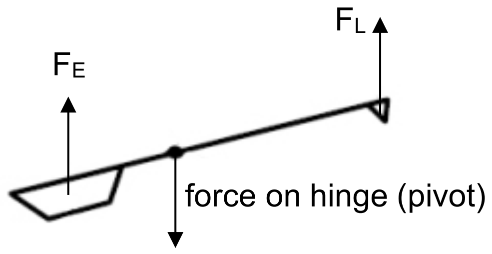
(b) Taking moments about P, at equilibrium, $N \times d_1 = F \times d_2$
$F = (N \times d_1) / d_2$, assuming N is the same.
If P is moved nearer towards B, distance d_2 would decrease, and d_1 would increase.
so F must increase.
Similarly, if P is moved nearer towards A, so F would decrease.



Example 5

(a) (i) *shown: F_L is force on tong by load (upwards)*

(ii)



(b) Consider forces on each tong (free-body diagram),

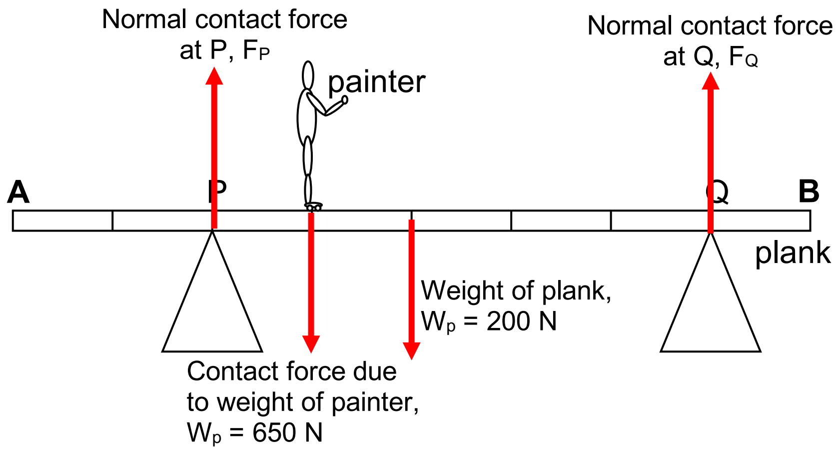
Taking moments about the pivot: $F_E \times 4.0 = F_L \times 10.0$

$F_E = 2.5\ F_L$ or $F_L = 0.40\ F_E$

(c) The distance is less than 4.0 cm. Assuming the same force F_E is exerted on the handle, $F_L < 0.40\ F_E$, the force on the load would be smaller.

Exercise 2

1. (a)



(b) *For plank to be in equilibrium, net moment = 0*

Take moments about Q, clockwise moments = anticlockwise moments

$(F_P \times 5\text{ m}) = (650\text{ N} \times 4\text{ m}) + (200\text{ N} \times 3\text{ m})$

$F_P = 640\text{ N}$

(c) *For plank to be in equilibrium, net force = 0*

$F_P + F_Q = 650\text{ N} + 200\text{ N}$

$F_Q = 210\text{ N}$

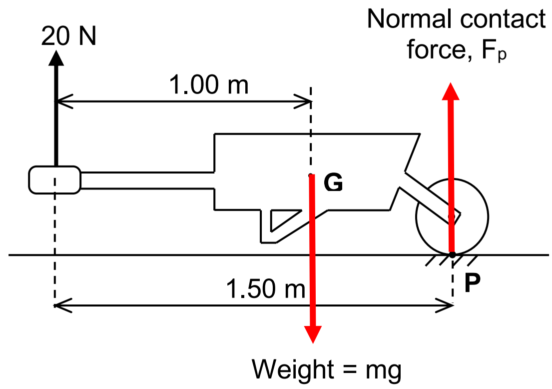
(d) Let d be shortest distance of painter from A. Just before plank topples, $F_Q = 0$ N.

Take moments about P, $650\text{ N} \times (2 - d) = 200\text{ N} \times 2\text{ m}$

$2\text{ m} - d = 0.6154\text{ m}$ ➔ $d = 1.385 \approx 1.4\text{ m}$

Ans: 1.4 m from A

2. (a)

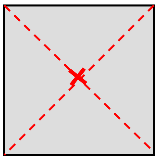


(b) (i) moment $= 20\text{ N} \times 1.50\text{ m}$
$= 30\text{ N m}$ clockwise

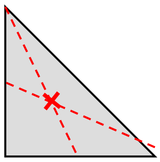
(ii) Take moments about P,
$mg \times 0.50\text{ m} = 30\text{ N m}$
$mg = 60\text{ N}$
$m = 6.0\text{ kg}$

Example 6

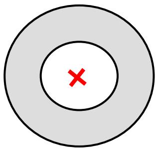
(a) (i)



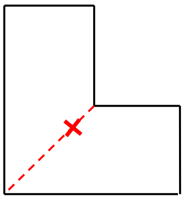
(ii)



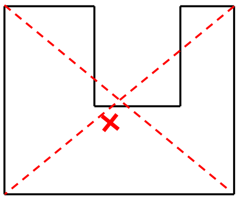
(iii)



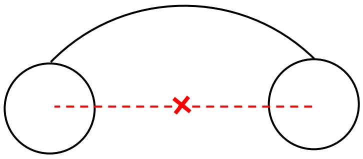
(b) (i)



(ii)

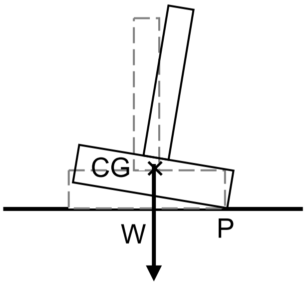


(iii)



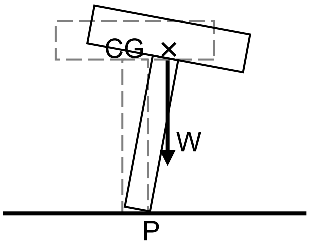
Example 7

(a) X in position 2



The weight W (acting at the CG) produces an anticlockwise moment about the pivot P.
Hence, the Bunsen burner X rotates anticlockwise back to its original position.

(b) Y in position 2



The weight W (acting at the CG) produces a clockwise moment about the pivot P.
Hence, the Bunsen burner Y rotates clockwise and topples.

(c) When Z is rolled slightly, its C.G. remains at the same position between the two points of Z in contact with the surface (P & Q). The weight W does not produce any moment about P or Q, so Z does not rotate at all.

Example 8 Answer: A

When the C.G. and the pivot are at the same point, the weight does not produce any moment, so no rotation.

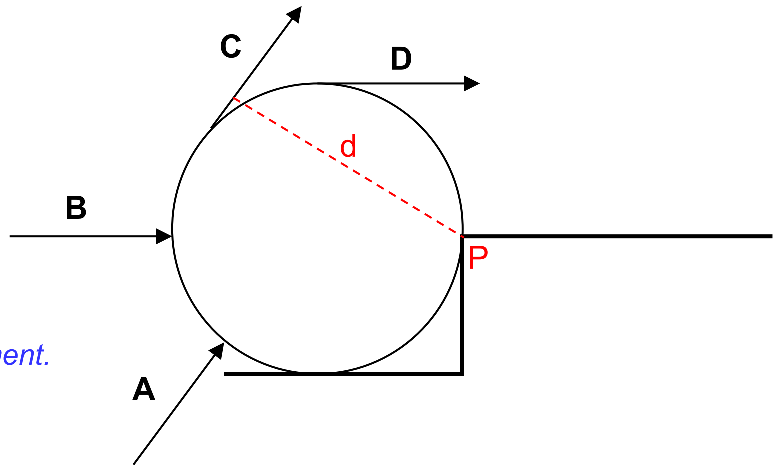
Exercise 3

1. Answer: C

moment = F × d

For the same turning moment about P,
Smallest F is needed
when d is the largest.
Forces at C gives the largest d.

Force at B passes through P, so no moment.



2. (a) Minimum initial force by Mike

$F_m \times 1.50$ m = 500 N $\times$ 0.55 m ➔ F_m = 183.3 N = 183 N (3 s.f.)

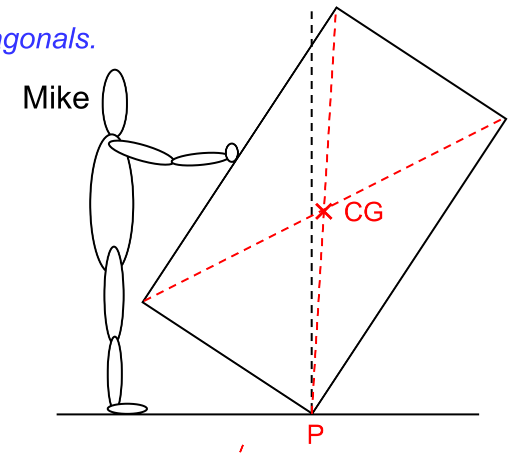
Minimum initial force by Pete

$F_p \times 1.20$ m = 500 N $\times$ 0.55 m ➔ F_p = 229.2 N = 229 N (3 s.f.)

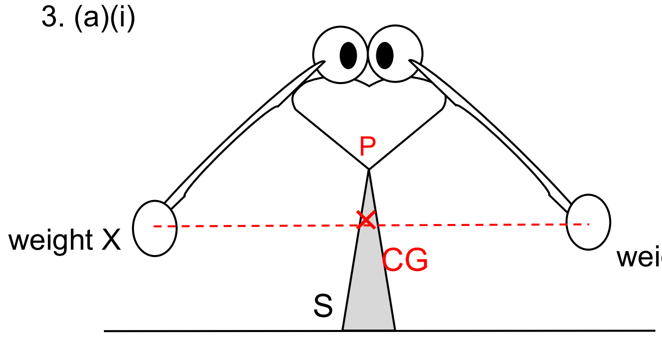
(b) Mike can apply the force at a position (top left corner) where its perpendicular distance from the line of action of the force to the pivot is greatest. Thus, the smallest force will be needed.

(c) (i) *The C.G. of the block is at the intersection of the two diagonals.*

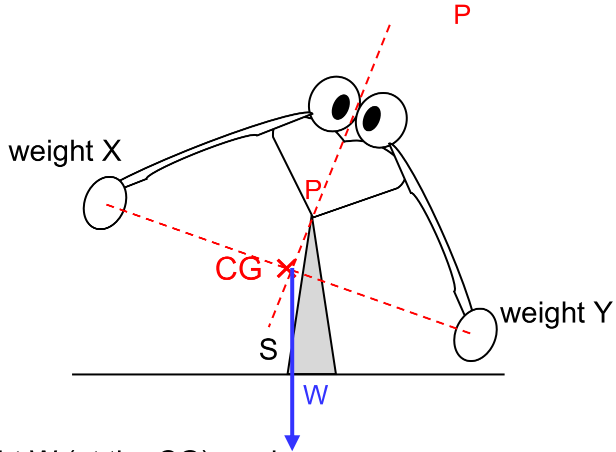
(ii) The weight at the C.G. would produce a clockwise moment about the pivot P. This would cause the block to rotate clockwise and topple over.



3. (a)(i)

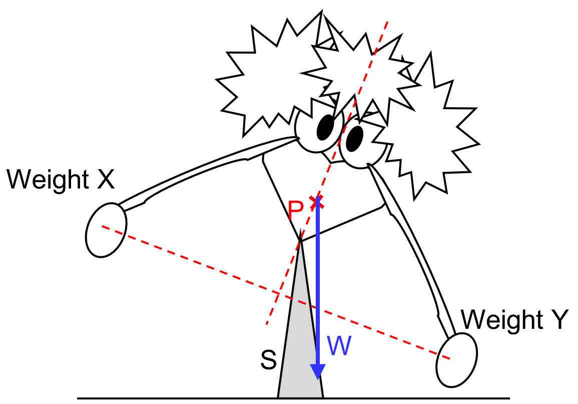


(ii)



(iii) The C.G. shifts to the left of the pivot. The weight W (at the CG) produces an anticlockwise moment about the pivot P. Hence, the toy rotates anticlockwise and returns to its original position.

(b)(i)



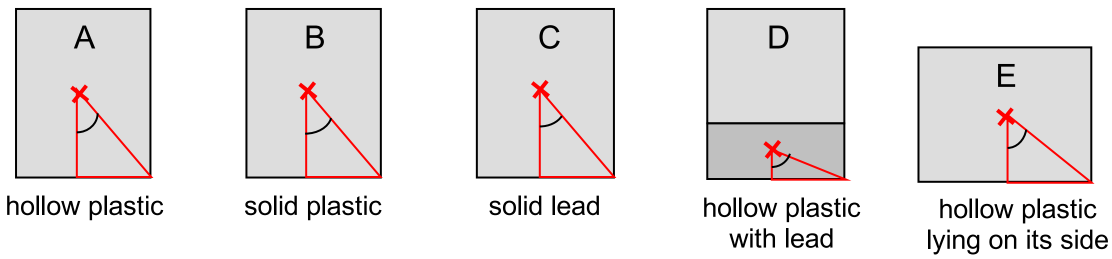
(ii) The C.G. shifts to the right side of the pivot. The weight W produces a clockwise moment about the pivot P, causing the toy to rotate clockwise and topple over.

Note: *Draw construction lines to locate the positions of C.G. accurately!*

Enrichment

Example 1

(a)



(i) D

(ii) A, B, C

(iii) Hardest to topple is C.
The weight of C is the largest and thus it creates the greatest moment about the pivot.
Therefore, the toppling force to overcome this moment is the largest.

Example 2

Let x be the maximum angle of tilt.

tan x = 8.0 / 15.0

x = $\tan^{-1}$ (0.533) = <u>28°</u>