



## Moments practice exam questions

Name \_\_\_\_\_ -

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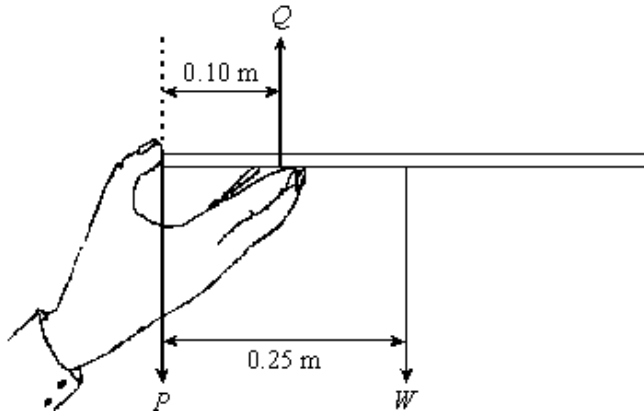
50 minutes



48 marks

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**Q1.** 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.

.....  
 .....  
 .....

(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).

.....  
 .....  
 .....

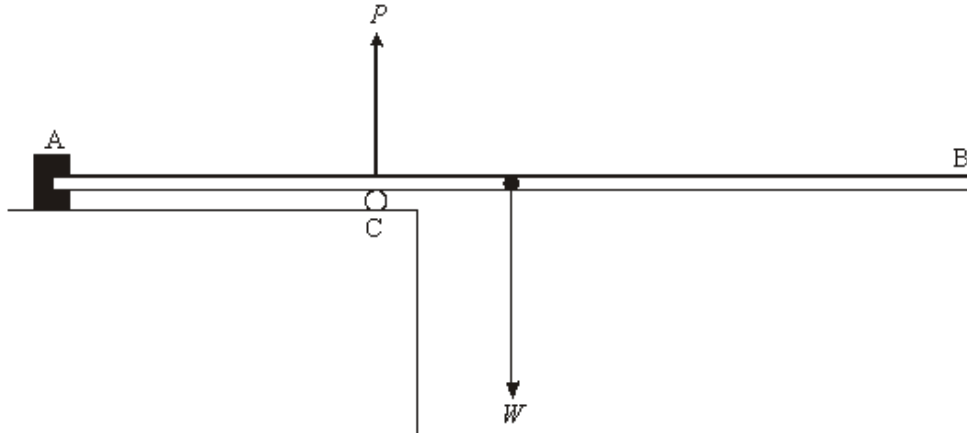
(2)  
 (Total 8 marks)

**Q2.** (a) Define the moment of a force.

.....  
.....

(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,  $W$ .

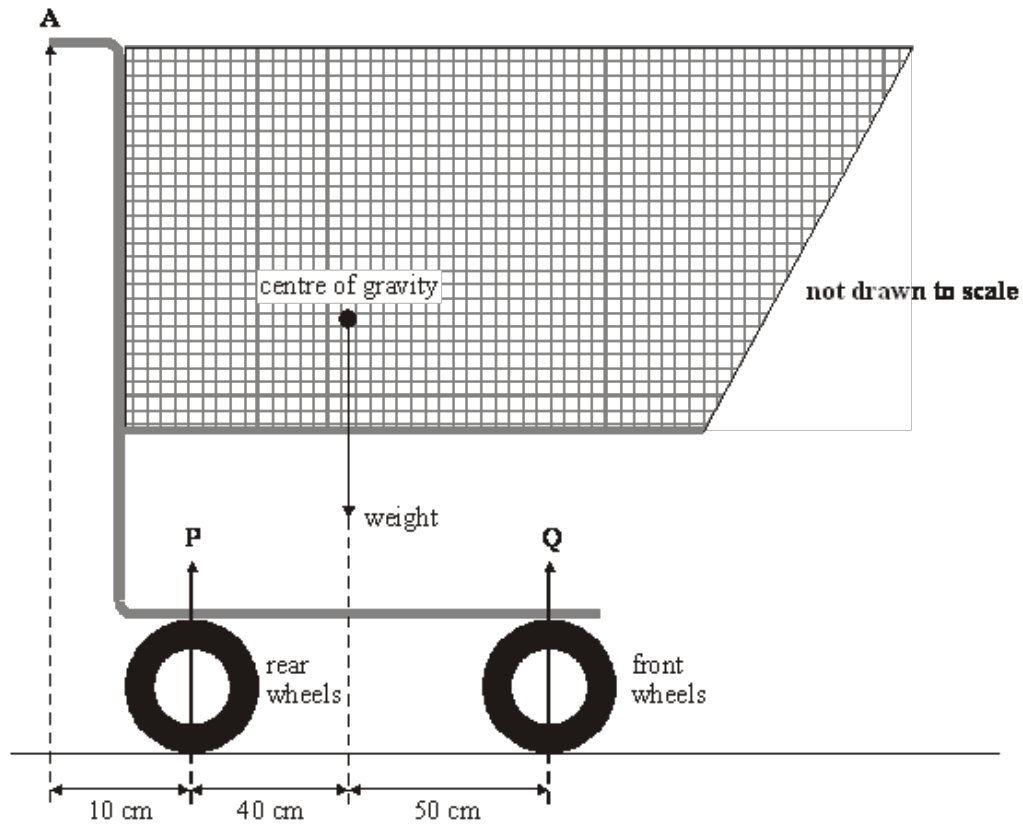
.....  
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(ii) State and explain what would be the effect on the force  $P$  of a girl walking along the board from A to B.

.....  
.....  
.....  
.....

(4)  
(Total 6 marks)

**Q3.** The figure below shows a supermarket trolley.



The weight of the trolley and its contents is 160 N.

(a) Explain what is meant by centre of gravity.

.....  
 .....

(2)

(b) **P** and **Q** are the resultant forces that the ground exerts on the rear wheels and front wheels respectively. Calculate the magnitude of

(i) force **P**,

.....  
 .....

(ii) force **Q**.

.....  
 .....

(3)

- (c) Calculate the minimum force that needs to be applied vertically at **A** to lift the front wheels off the ground.

.....  
.....  
.....

(2)

- (d) State and explain, without calculation, how the minimum force that needs to be applied vertically at **A** to lift the rear wheels off the ground compares to the force you calculated in part (c).

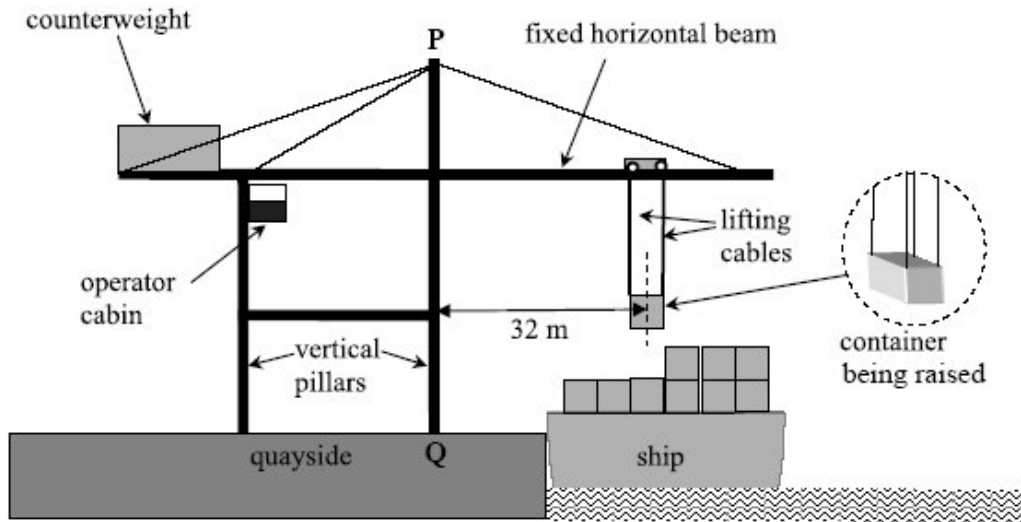
You may be awarded marks for the quality of written communication in your answer.

.....  
.....  
.....  
.....

(3)

**(Total 10 marks)**

**Q4.** The diagram below shows a dockside crane that is used to lift a container of mass 22000 kg from a cargo ship onto the quayside. The container is lifted by four identical 'lifting' cables attached to the top corners of the container.



(a) When the container is being raised, its centre of mass is at a horizontal distance 32 m from the nearest vertical pillar **PQ** of the crane's supporting frame.

(i) Assume the tension in each of the four lifting cables is the same. Calculate the tension in each cable when the container is lifted at constant velocity.

answer ..... N

(2)

(ii) Calculate the moment of the container's weight about the point **Q** on the quayside, stating an appropriate unit.

answer .....

(3)

(iii) Describe and explain one feature of the crane that prevents it from toppling over when it is lifting a container.

.....  
 .....  
 .....  
 .....  
 .....

(2)

- (b) Each cable has an area of cross-section of  $3.8 \times 10^{-4} \text{ m}^2$ .
- (i) Calculate the tensile stress in each cable, stating an appropriate unit.

answer .....

(3)

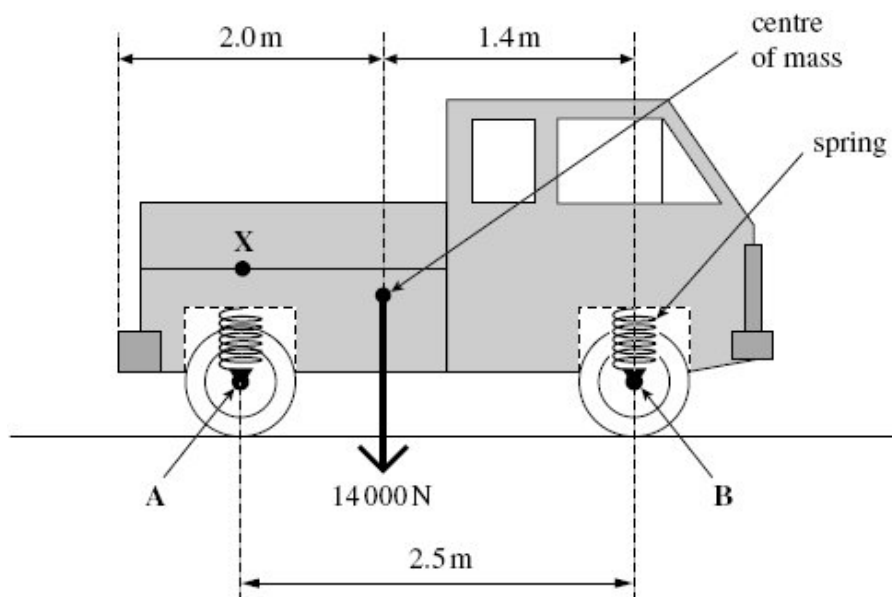
- (ii) Just before the container shown in the diagram above was raised from the ship, the length of each lifting cable was 25 m. Show that each cable extended by 17 mm when the container was raised from the ship.

Young modulus of steel =  $2.1 \times 10^{11} \text{ Pa}$

(2)

(Total 12 marks)

- Q5.** 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.

.....  
.....  
.....  
.....

(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  $100\,000\text{ N m}^{-1}$ .

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)

- M1.** (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)  $W = 0.12 \times 9.81 = 1.2 \text{ N}$  (1) (1.18N)
- (iii) (taking moments about P gives)  
 $Q \times 0.1 = 0.12 \times 9.81 \times 0.25$  (1)  
 $Q = 2.9 \text{ N}$  (2.94 N) (1)  
 $P = 2.9 - 1.2 = 1.7 \text{ N}$  (1) (or  $2.94 - 1.18 = 1.76 \text{ N}$ )  
 (allow C.E. for values of  $W$  and  $Q$ )
- 6
- (b) placed at Q (1)  
 no additional turning moment about Q (1)
- 2
- [8]

- M2.** (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]

- M3.** (a) the point (in a body) (1)  
 where the weight (or gravity) of the object appears to act  
 [or resultant torque zero] (1)
- 2
- (b) (i)  $P \times 0.90 = 160 \times 0.50$  (1)  
 $P = 89 \text{ N}$  (88.9 N)
- (ii)  $Q = (160 - 89) = 71 \text{ N}$  (1)  
 (allow C.E. for value of  $P$  from (i))
- 3

(c) (minimum) force  $\times 0.10 = 160 \times 0.40$  **(1)**

force = 640 N **(1)**

2

(d) force is less **(1)**

because distance to pivot is larger **(1)**

smaller force gives large enough moment (1)

3

[10]

**M4.** (a) (i) weight of container ( $= mg = 22000 \times 9.8(1) = 2.16 \times 10^5$  (N) **(1)**

tension ( $= \frac{1}{4} mg$ ) = (5.39)  $5.4 \times 10^4$  (N) or divide a weight by 4 **(1)**

(ii) moment ( $= \text{force} \times \text{distance}$ ) =  $22000 g \times 32$  **(1)** ecf weight in (a) (i)

=  $6.9$  or  $7.0 \times 10^6$  **(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 ( $= \frac{\text{tension}}{\text{csa}}$ ) =  $\frac{5.4 \times 10^4}{3.8 \times 10^{-4}}$  ecf (a) (i) **(1)**

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

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

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

5

[12]

**M5.** (a) (i) force  $\times$  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)  $(F = k\Delta) \frac{F}{k}$  or  $(\Delta) = \frac{(a)(iii)}{1000000}$  **(1)**  
 $= 0.039$  (m) **(1)** ecf

2

(c)  $F = (100000 \times 0.065) = 6500$  (N) **(1)**

$F = (2 \times 6500) = 13000$  (N) **(1)**

2

[12]

