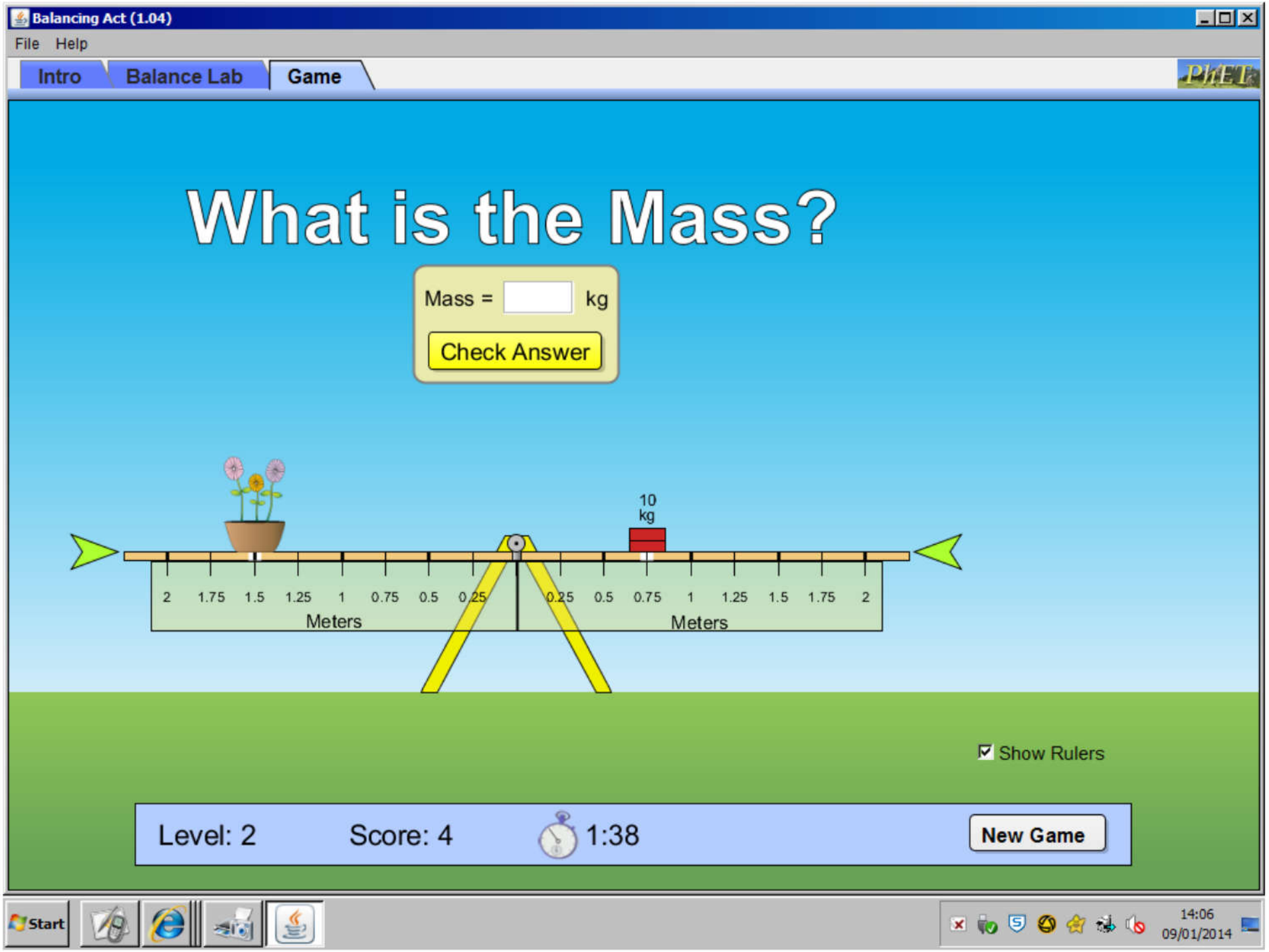
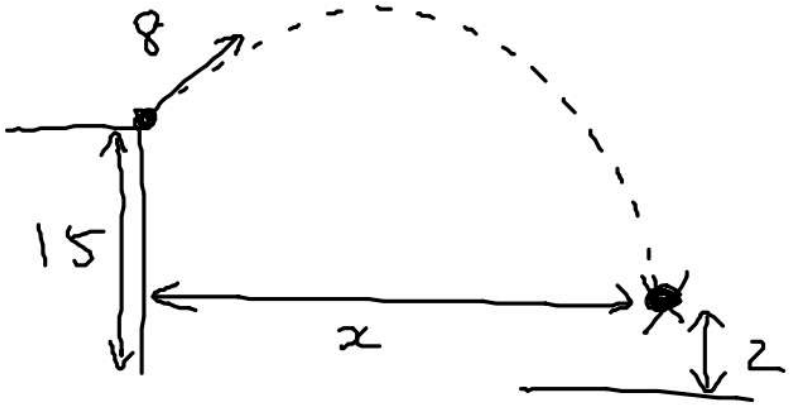

Balancing Act (1.04)
File Help
Intro
Balance Lab
Game
PhET
What is the Mass?
Mass =
kg
Check Answer
10
kg
2 1.75 1.5 1.25 1 0.75 0.5 0.25
Meters
0.25 0.5 0.75 1 1.25 1.5 1.75 2
Meters
Show Rulers
Level: 2
Score: 4
1:38
New Game
Start
14:06
09/01/2014

Ex 6D Q56

5a) $y = x\tan\alpha - \dfrac{gx^2}{2u^2\cos^2\alpha}$

$y = x\tan\alpha - \dfrac{gx^2}{2u^2}(1+\tan^2\alpha)$

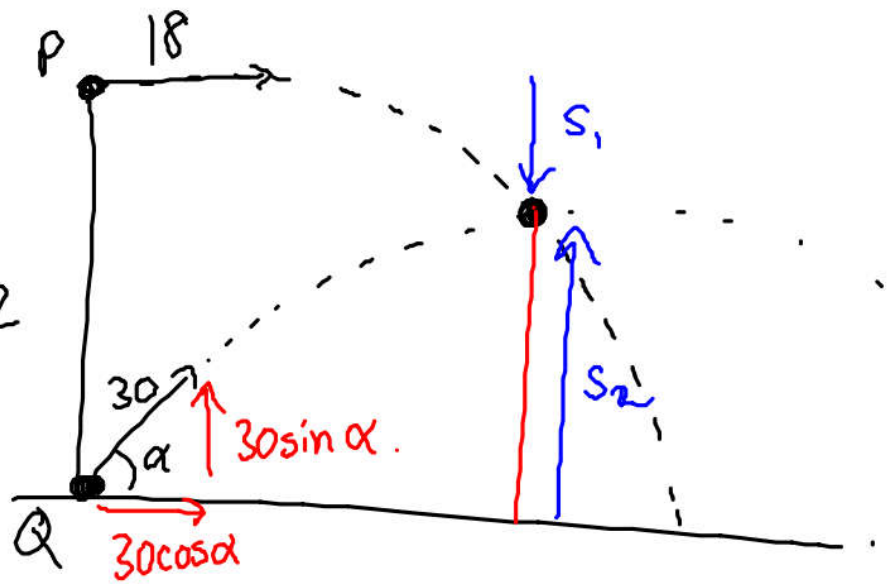
$-13 = x\tan 40 - \dfrac{10x^2}{2\times 8^2}(1+\tan 40)$



$u = 8$

$\alpha = 40°$

9)



P, horizontal

speed = 18

dist = x

time = t

$x = 18t$

Q, horizontal

speed = $30\cos\alpha$

dist = x

time = t

$x = 30\cos\alpha \times t$

$18t = 30\cos\alpha \times t$

$\frac{18}{30} = \cos\alpha$

$\cos\alpha = \frac{3}{5}$

P vertical ↓+

$S = S_1$

$a = 9.8$

$u = 0$

$t = t$

$S_1 = 4.9t^2$

Q vertical ↑+

$S = S_2$

$u = 30 \times \frac{4}{5} = 24$

$a = -9.8$

$t = t$

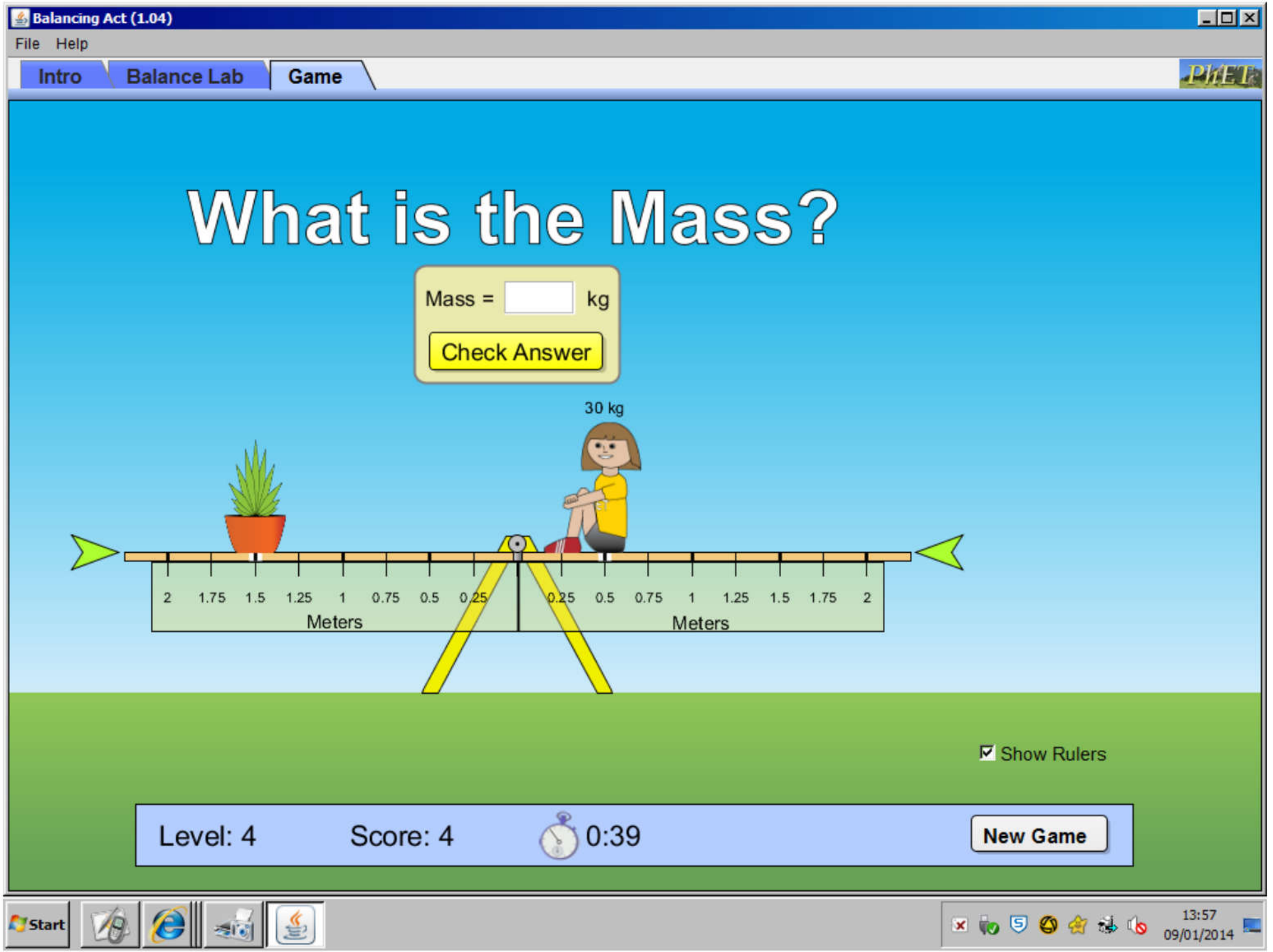
$S_2 = 24t - 4.9t^2$

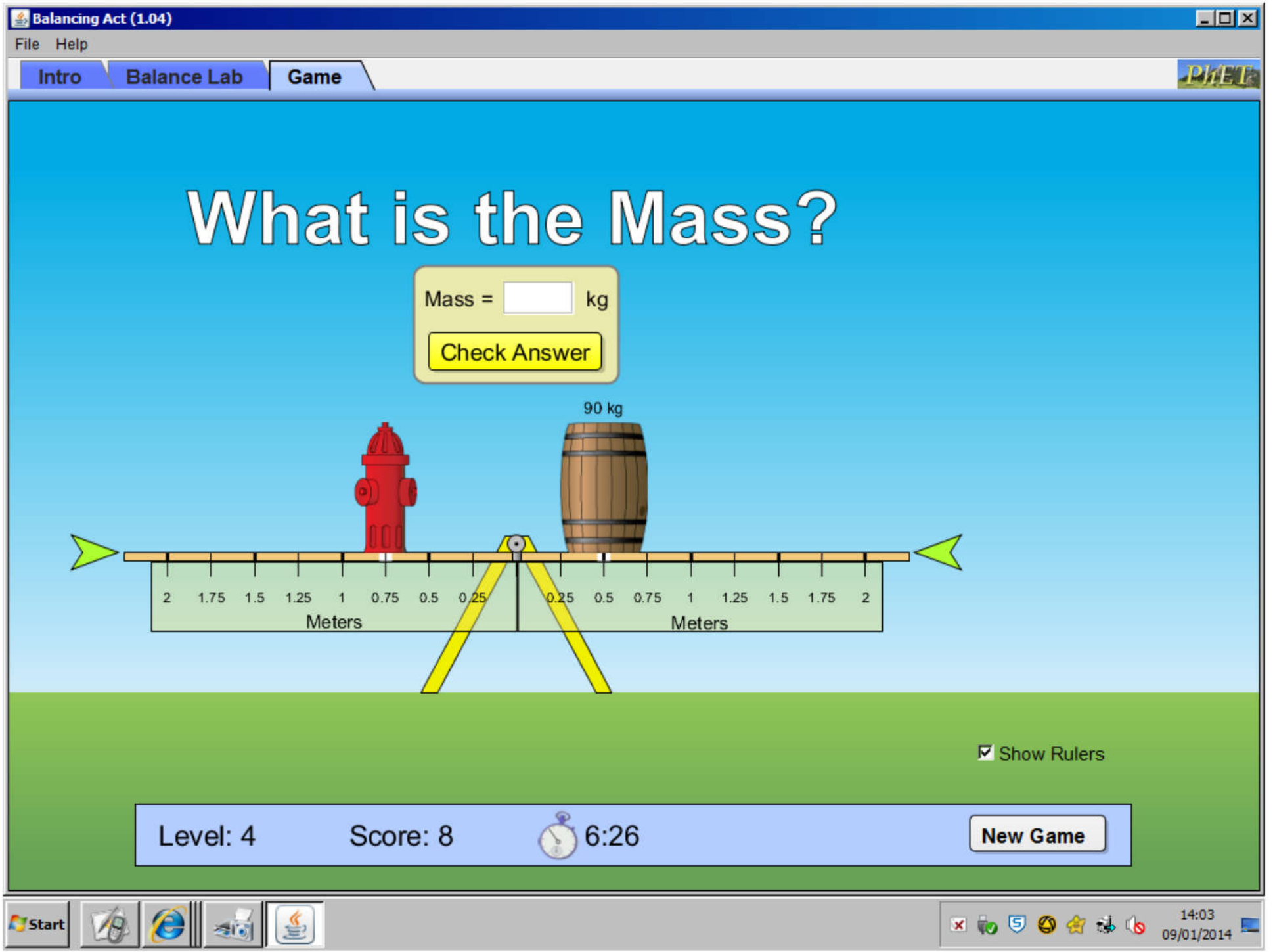
$S_1 + S_2 = 32$

$4.9t^2 + 24t - 4.9t^2 = 32$

$t = \frac{32}{24} = \frac{4}{3}$

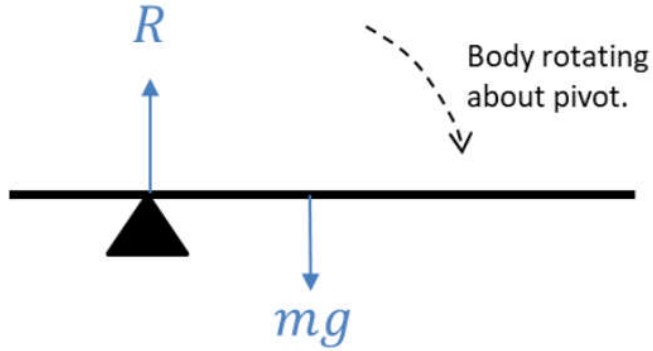
$= 1.3$ secs


Balancing Act (1.04)
File Help
Intro
Balance Lab
Game
PhET
What is the Mass?
Mass =
kg
Check Answer
30 kg
2 1.75 1.5 1.25 1 0.75 0.5 0.25
Meters
0.25 0.5 0.75 1 1.25 1.5 1.75 2
Meters
Show Rulers
Level: 4
Score: 4
0:39
New Game
Start
13:57
09/01/2014


Balancing Act (1.04)
File Help
Intro
Balance Lab
Game
PhET
What is the Mass?
Mass =
kg
Check Answer
90 kg
2 1.75 1.5 1.25 1 0.75 0.5 0.25
Meters
0.25 0.5 0.75 1 1.25 1.5 1.75 2
Meters
Show Rulers
Level: 4
Score: 8
6:26
New Game
Start
14:03
09/01/2014

Rigid Bodies

We previously dealt with particles, where each object was modelled just as a single point, and considered forces acting on each point separately.



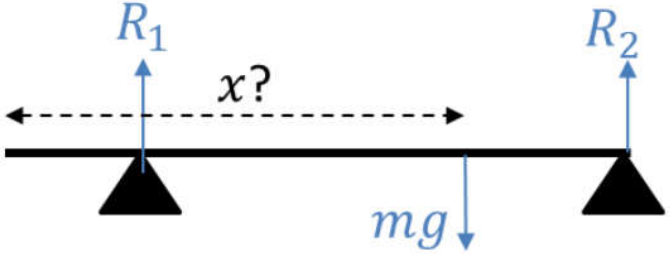
In this chapter we consider rigid bodies (in this case **rods**), which takes into account the size of the object. This means we can consider other properties, e.g. **rotation** of the body.

1:: Moments in equilibrium

Clockwise moment = Anticlockwise moment

2:: Centre of Mass

For a 'non-uniform' rod we can't model its weight as acting at the centre.



3:: On the point of Tilting

"A non uniform wooden plank of mass M kg rests horizontally on supports at A and B, as shown. When a bucket of water of mass 18kg is placed at point C, the plank is in equilibrium, and is **on the point of tilting** about B. Find the value of M and the magnitude of the reaction at B."

Key Questions

a) What does it mean if a rod/beam is uniform?

b) What does it mean if a rod/beam is non-uniform?

c) What does it mean if a rod/beam is on the point of tilting about A?

d) Why might you take moments from different points on the beam?

e)There are only 2 things you can do in a moments question. What are they?

Moments

The 'moment' of a force measures the **turning effect** of the force on the body on which it is acting.

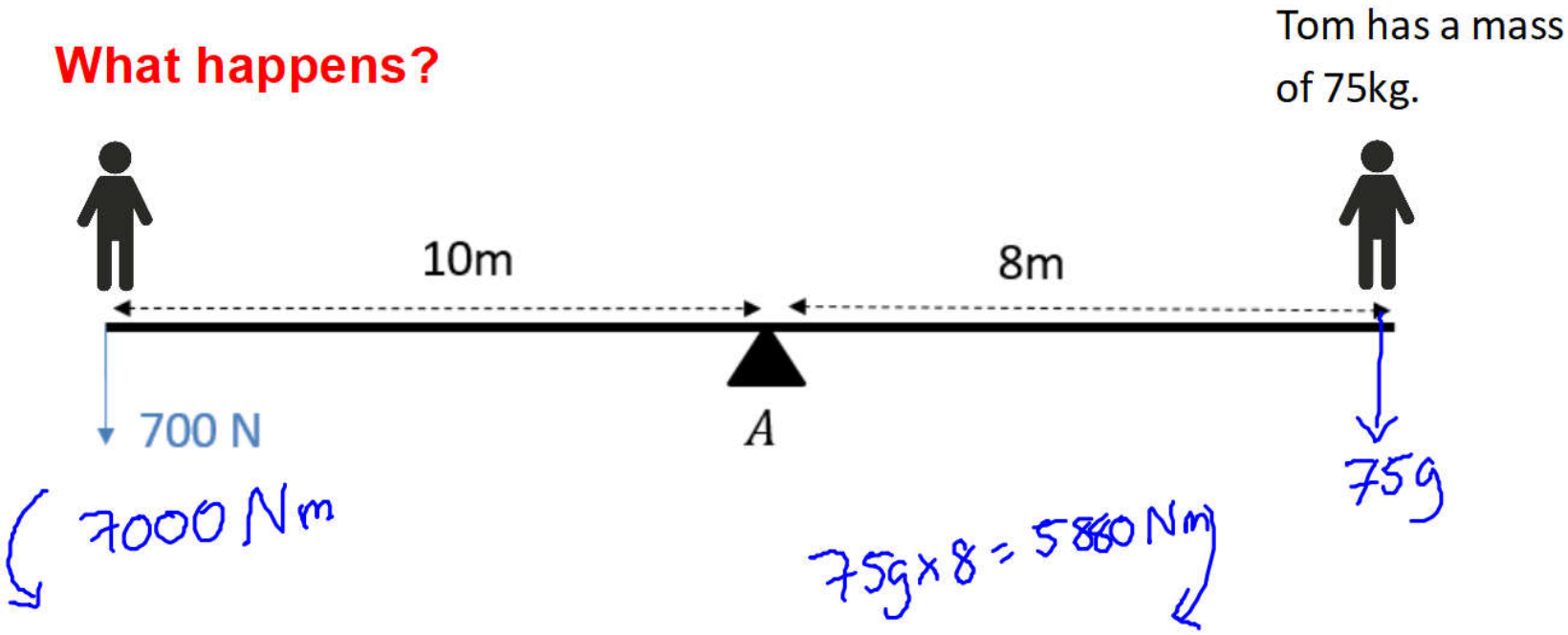
perp. force × dist.

$$\textit{moment of force} = \textit{force} \times \textit{distance}$$

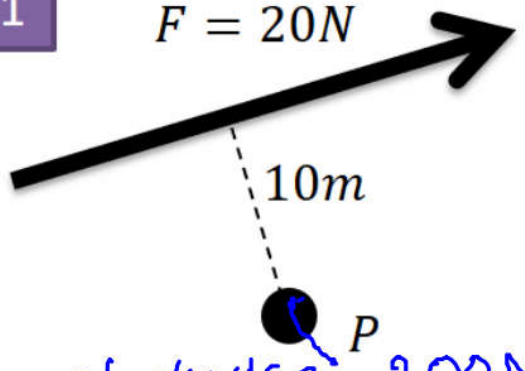
about a point (any point you choose)

perpendicular distance

What happens?



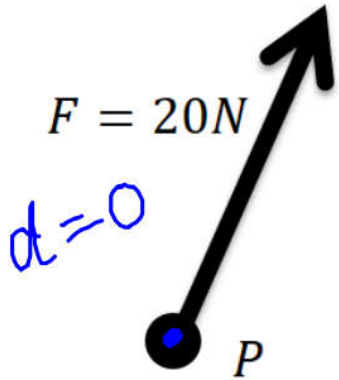
1



clockwise 200Nm

Moment of force F about point P

2

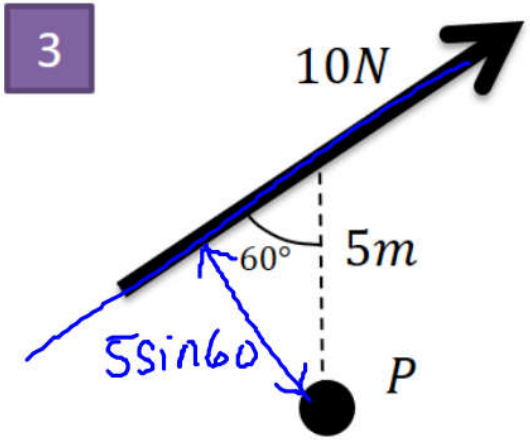


$d = 0$

zero moment

Moment of force F about point P

3



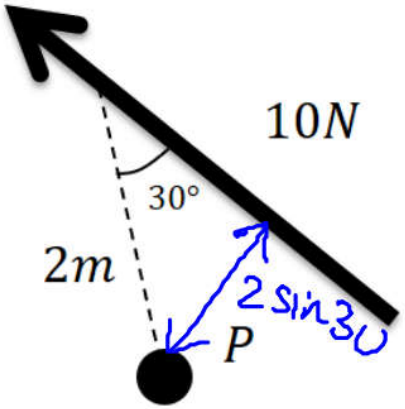
Moment of force F about point P

clockwise

$10 \times 5\sin 60$

$50\sin 60 = 25\sqrt{3}$ Nm

4

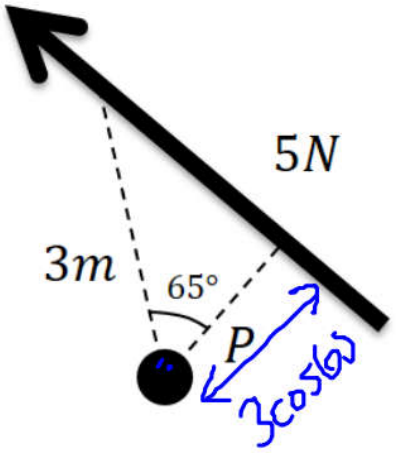


a.c.

$10 \times 2\sin 30$

Moment: 10 Nm ↻

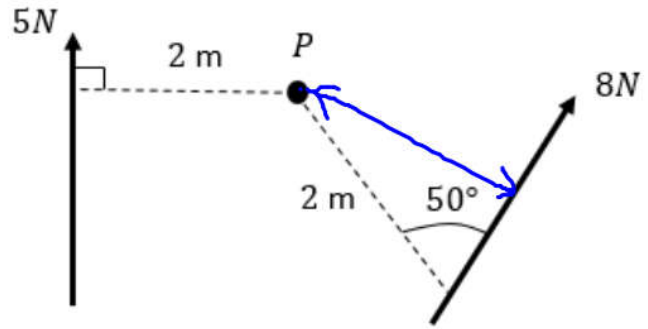
5



Moment:

$5 \times 3\cos 65 = 15\cos 65$ ↻

The diagram shows two forces acting on a lamina. Find the moment of each of the forces about the point P.



Terminology: A *lamina* is a 2D object whose thickness can be ignored.

clockwise moment = $5 \times 2 = 10$ Nm

anti-clockwise moment = $8 \times 2 \sin 50 = 12.3$ Nm (3sf)

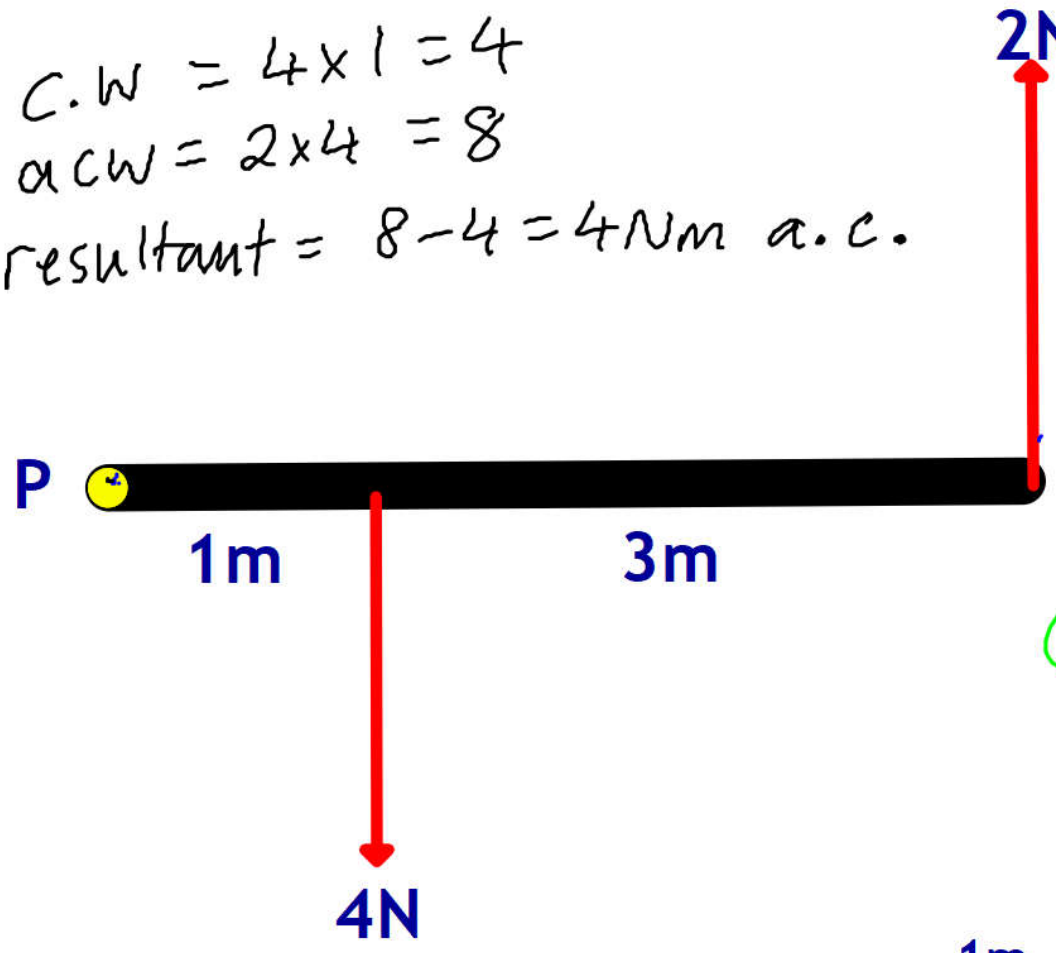
resultant = 2.3N (2sf) anticlockwise.

Resultant Moments

C.W = 4x1 = 4

a.c.w = 2x4 = 8

resultant = 8 − 4 = 4Nm a.c.



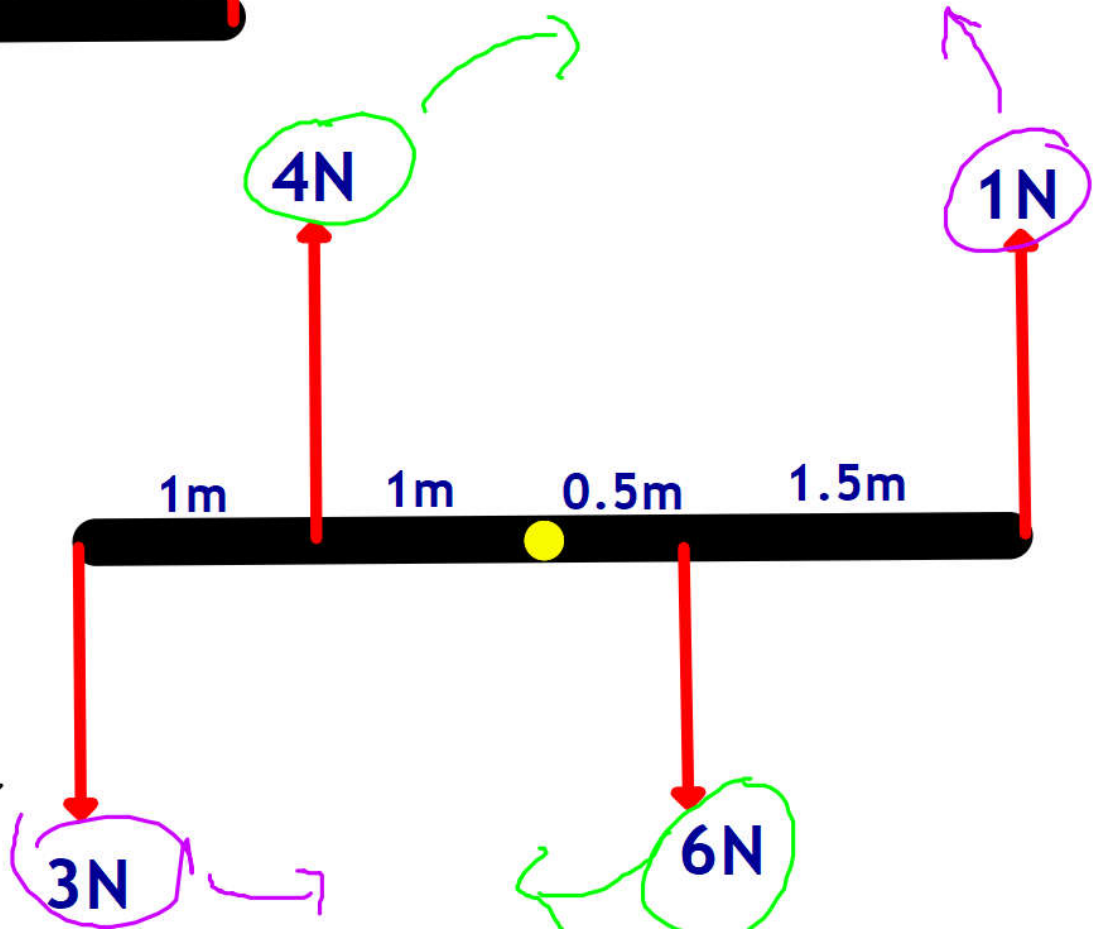
a.c = 3x2 + 1x2

= 8Nm

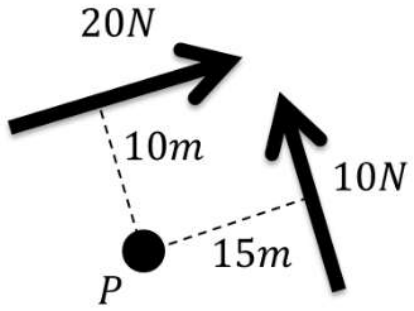
c = 4x1 + 6x0.5

= 7Nm

resultant = 1Nm a.c.



1

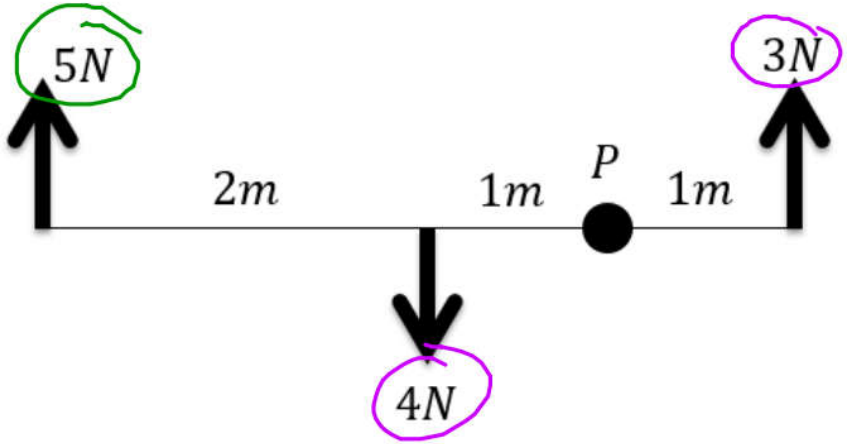


C. = 20×10 = 200

a.c. = 15×10 = 150

50Nm clockwise.

2

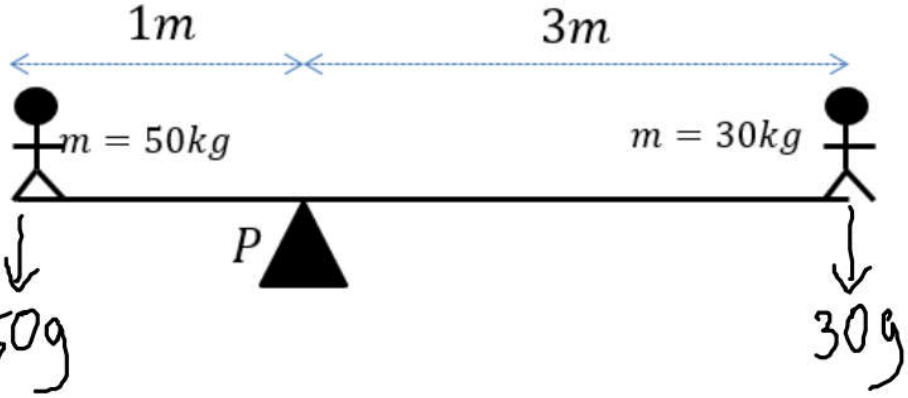


a.c. = 4×1 + 3×1 = 7Nm

C = 5×2 = 10Nm

resultant = 3Nm clockwise

3



(Rod is light)

30g×3 = 90g

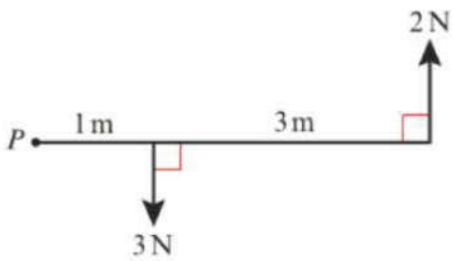
50g×1 = 50g

resultant 40g clockwise.

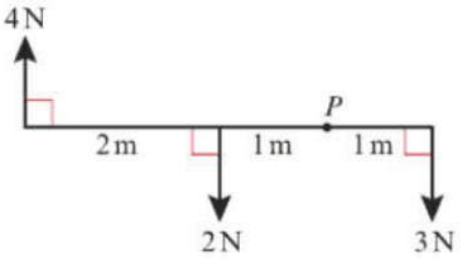
Exercise 4B

1 These diagrams show sets of forces acting on a light rod. In each case, calculate the resultant moment about P.

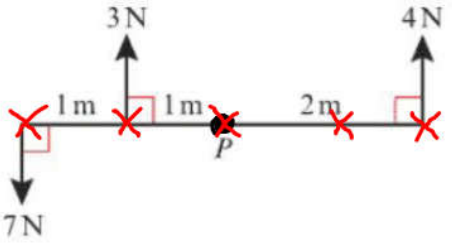
a



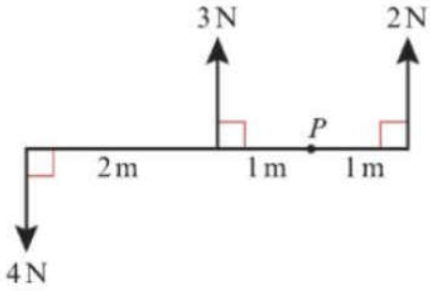
b



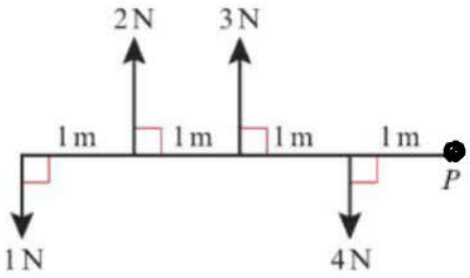
c



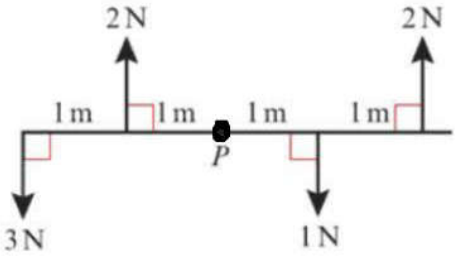
d



e

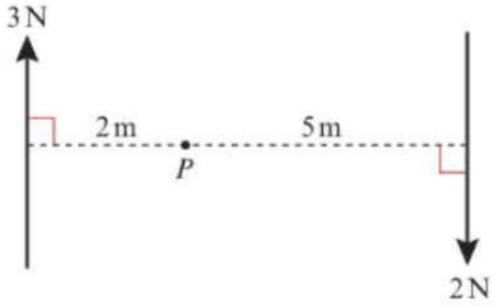


f

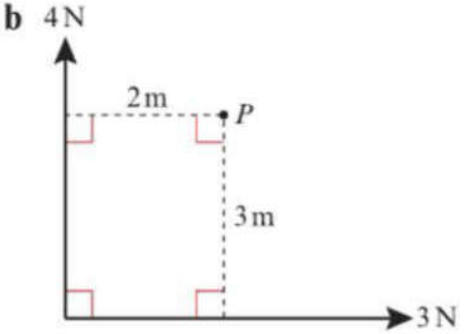


2 These diagrams show forces acting on a lamina. In each case, find the resultant moment about P.

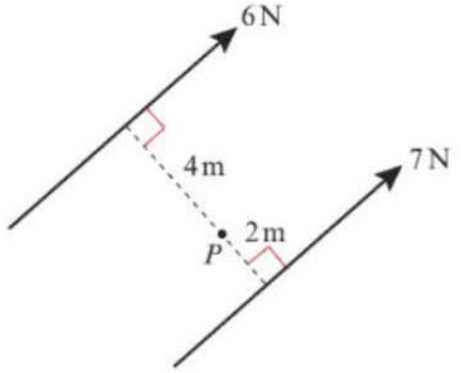
a



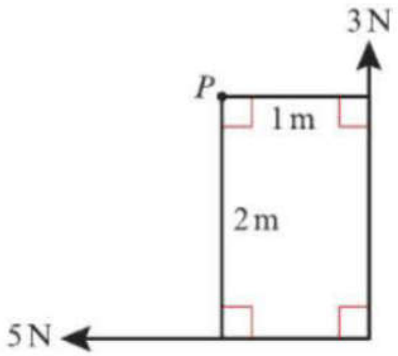
b



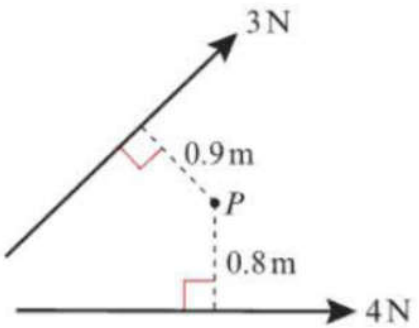
c



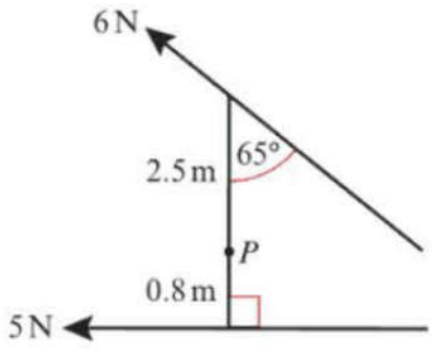
d



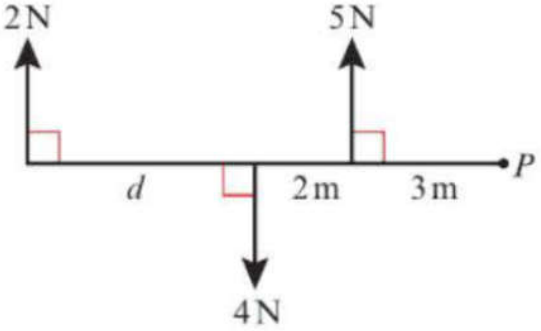
e



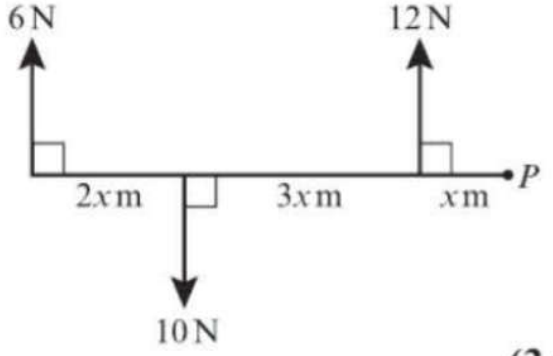
f



(P) **3** The diagram shows a set of forces acting on a light rod.
The resultant moment about P is 17 N m clockwise.
Find the length, d.



(E/P) **4** The diagram shows a set of forces acting on a light rod.
The resultant moment about P is 12.8 N m clockwise.
Find the value of x.



(3 marks)

Exercise 4B

1 **a** 5 Nm anticlockwise **b** 13 Nm clockwise
c 19 Nm anticlockwise **d** 11 Nm anticlockwise
e 4 Nm clockwise **f** 7 Nm anticlockwise

2 **a** 16 Nm clockwise **b** 1 Nm anticlockwise
c 10 Nm clockwise **d** 7 Nm clockwise
e 0.5 Nm anticlockwise **f** 9.59 Nm anticlockwise

3 6 m

4 1.6

This entire topic summarised…

If a rigid body is in **equilibrium** then:

a The resultant force in any direction is 0.
b The resultant moment about any point is 0.

i.e. Forces up = forces down, as per Year 1

In other words, clockwise moments = anticlockwise moments

You will typically use **both** these properties to solve exam questions.

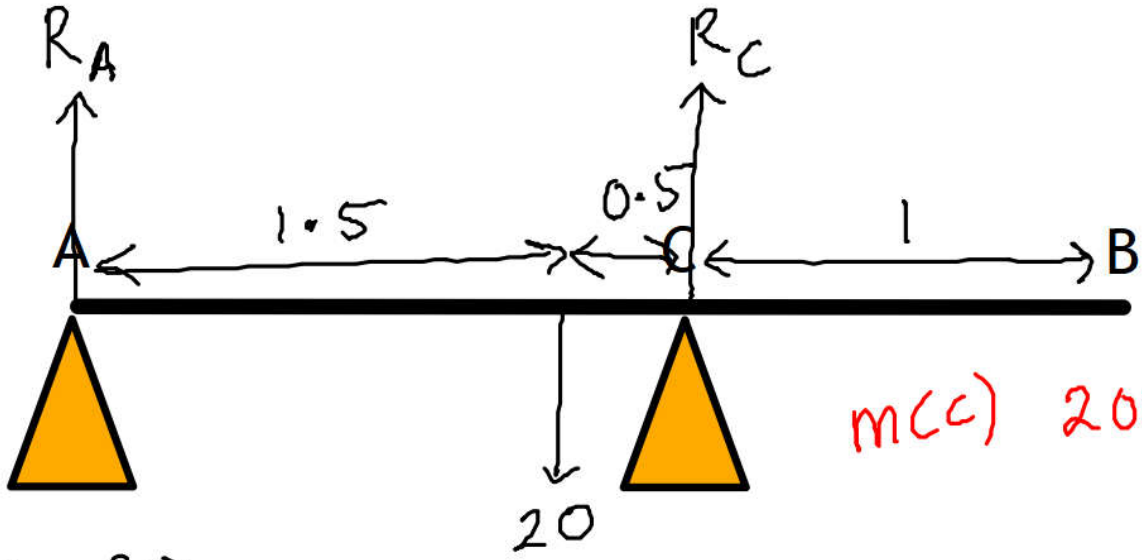
Rigid Bodies in Equilibrium

mass spread evenly

Where does weight act on a body? centre!

A uniform rod AB of length 3m and weight 20N rests horizontally on supports at A and C, where AC = 2m. (see diagram)

Calculate the magnitude of the reaction at each of the supports.



$(R\updownarrow)$ $R_A + R_C = 20$

$m(A)$ $20 \times 1.5 = 2R_C$

$30 = 2R_C$

$R_C = 15$

$m(C)$ $20 \times 0.5 = 2R_A$

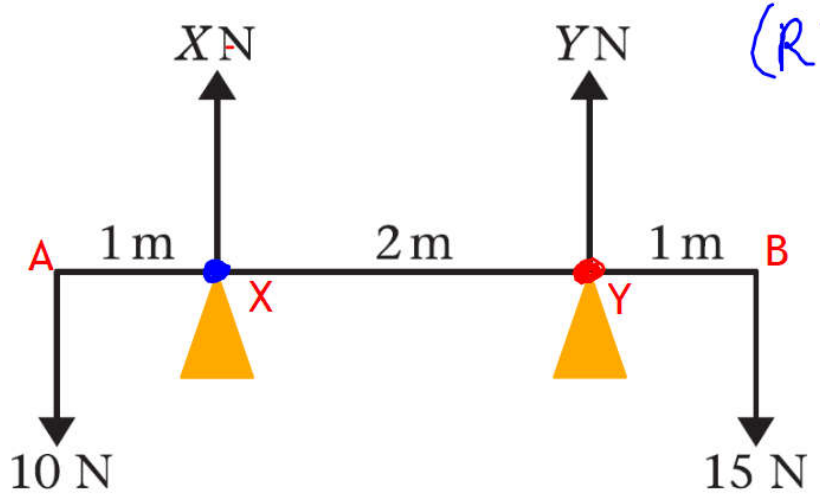
$10 = 2R_A$

$R_A = 5$

$R_A = 5$

- Weights and reactions ✓
- Moments ✓
- Resolving vertically

Given that the rod is in equilibrium, find the values of X and Y



(R↕)

$X + Y = 25$

M(X) $2Y + 10 \times 1 = 15 \times 3$

$2Y + 10 = 45$

$2Y = 35$

$Y = 17.5$

$X = 25 - 17.5$

$= 7.5\ N$

M(A) $X + 3Y = 15 \times 4$

$X + 3Y = 60$

M(Y) $2X + 15 = 30$

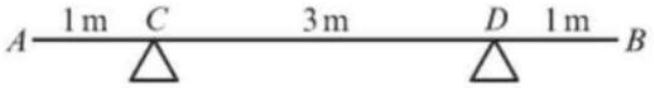
$2X = 15$

$X = 7.5\ N$

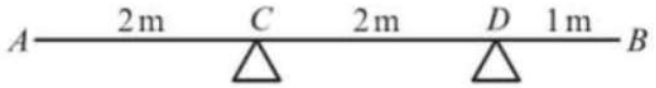
Exercise 4C

1 AB is a uniform rod of length 5 m and weight 20 N. In these diagrams AB is resting in a horizontal position on supports at C and D. In each case, find the magnitudes of the reactions at C and D.

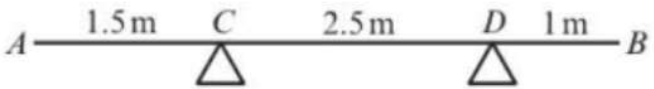
a



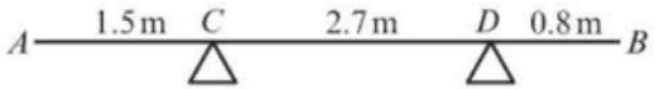
b



c

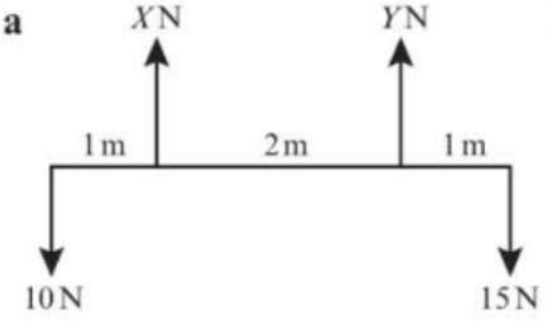


d

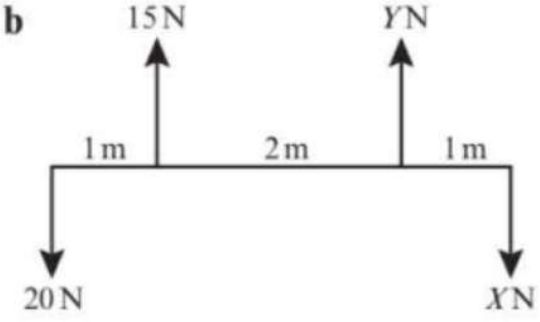


2 Each of these diagrams shows a light rod in equilibrium in a horizontal position under the action of a set of forces. Find the values of the unknown forces and distances.

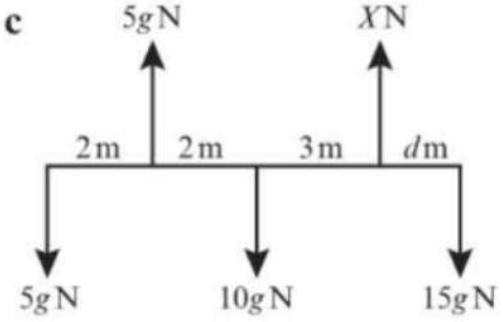
a



b



c



3 Jack and Jill are playing on a seesaw made from a uniform plank AB, of length 5 m pivoted at M, the midpoint of AB. Jack has mass 35 kg and Jill has mass 28 kg. Jill sits at A and Jack sits at a distance x m from B. The plank is in equilibrium. Find the value of x.

Exercise 4C

1 **a** 10N, 10N **b** 15N, 5N
c 12N, 8N **d** 12.6N, 7.4N

2 **a** 7.5, 17.5 **b** 30, 35 **c** 245, $2\frac{2}{3}$

3 0.5 m