Projectile Motion

A **projectile** is an object that has been given an initial velocity by some sort of short-lived force, and then moves through the air under the influence of gravity.

Be able to:

- Know what a projectile is
- Use the projectile motion equations to solve problems (Type 1, Type 2, Type 3)

Rules of Projectile Motion:

	Horizontal	Vertical
Acceleration	$a_x = 0$	$a_y = -g$
Velocity	$v_x = v\cos\theta$	$v_y = -gt + v\sin\theta$
Displacement	$x = v\cos\theta t + c$	$y = -g\frac{t^2}{2} + v\sin\theta t + c$

Question types:
Type 1 - Start and finish at same height

Type 2 - Start high

Type 3 - Start low and finish high (or vice versa)

Relative Velocity

$v_{PA} = v_{PB} + v_{BA}$

The velocity of P relative to A is the velocity of P relative to B plus the velocity of B relative to A.

Suppose you are riding your bike. To another bike rider riding alongside, you appear to be stationary. In other words, the velocity of a particle depends on the reference frame of whoever is observing or measuring the velocity.

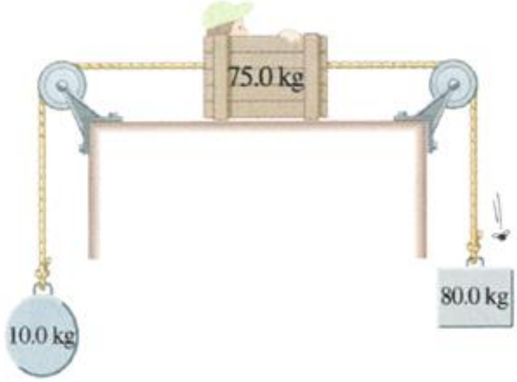
Paper 2 Questions

Q1. Helen stands on the rock surface of a mountain. The soles and heels of her hiking boots have a static friction coefficient equal to 1.0.

a) Show that the steepest slope she can stand on is 45° to the horizontal. [3 marks]

b) Her hiking shorts have a static friction coefficient of 0.30. What happens if she sits down to rest? (i.e. at what angle would she slide down the mountain?) [2 marks]

Q2. Consider the system of three masses joined by light ropes. The pulleys are frictionless.

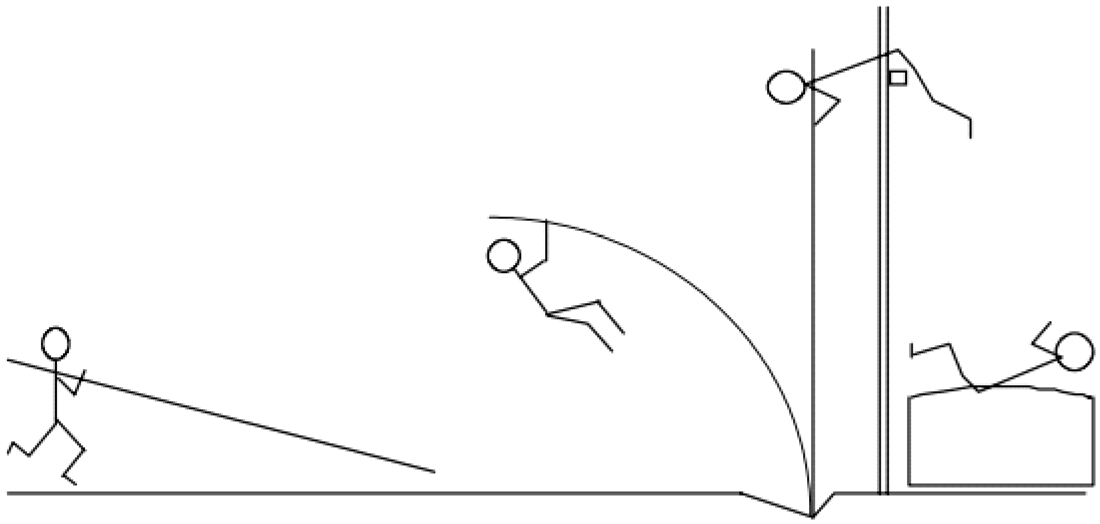


a) If the surface of the table is frictionless, calculate the acceleration of the box. [4 marks]

b) Now assume the table surface has friction and the three bodies in the diagram are at rest. However if a fly lands on the 80.0 kg mass then the system begins to move. What is the static friction coefficient for the box and table surface? [2 marks]

Energy Narrative Example

In the pole vault event an athlete runs as fast as possible towards the bar, holding a flexible fibreglass pole. He sticks the end of the pole into a slot in the ground, swings up on the pole and over the bar as shown (not to scale).



(a) Describe the energy transformations that occur for the athlete and the pole during the event. *[4]*

(a) *Any four of the following five energy aspects, provided the narrative makes sense.*

- KE in runup; ***[1]***
- Is converted to Elastic PE and Gravitational PE while swinging up on bending pole; ***[1]***
- Also muscular energy used doing work while going up; ***[1]***
- Energy is nearly all Gravitational PE at top of vault; ***[1]***
- PE converted to KE on way down ***[1]***

[4 max]

Momentum

Be able to:
- Know what momentum is and how to calculate it

- Momentum is mass times velocity
- Momentum has direction
- Its unit is **kg m s^{-1}**
- The **principle of conservation of momentum** states that the initial momentum is the same as the final momentum following an interaction. When net force on a system is zero the total momentum is constant. (Important to say one of these sentences in momentum questions).

$$\boldsymbol{p = mv}$$

<u>Kinetic energy in terms of momentum</u>

$$E_k = \frac{1}{2}mv^2$$
$$= \frac{1}{2}m\left(\frac{p}{m}\right)^2$$
$$= \frac{mp^2}{(2m^2)}$$
$$= \frac{p^2}{2m}$$
$$\boldsymbol{E_k = \frac{p^2}{2m}}$$

<u>Newton's second law in terms of momentum</u>

$$F_{net} = ma$$
$$= m\left(\frac{\Delta v}{\Delta t}\right)$$
$$= \frac{m\,\Delta v}{\Delta t}$$
$$= \frac{\Delta p}{\Delta t}$$
$$\boldsymbol{F_{net} = \frac{\Delta p}{\Delta t}}$$