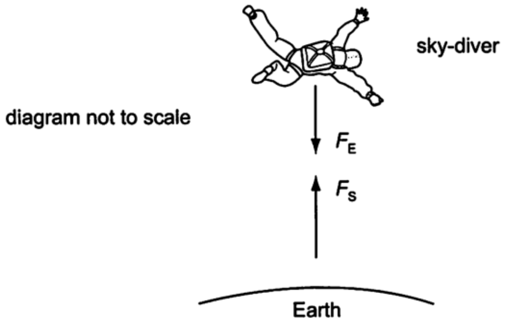
TOPIC 3: DYNAMICS QUIZ **Time: 30 minutes** **Score: / 19**

Name: ___________________________ **CG:** ______________

1 A skydiver jumps from an aircraft. The Earth exerts a downwards force F_E on the skydiver who also exerts an upward force F_s on the Earth. [N11P1Q5]



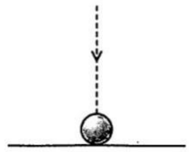
Which statement is correct?

A the magnitude of F_E > the magnitude of F_s
B the magnitude of F_E < the magnitude of F_s
C the magnitude of F_E = the magnitude of F_s and they cancel each other out
D the magnitude of F_E = the magnitude of F_s and they do not cancel each other out

2 A man of mass 60 kg is in a lift ascending at a uniform speed 3 ms^{-1}. Determine the magnitude of the force acting on the man by the floor of the lift? [1]

3 A ball of mass 80 g collides with a vertical wall. The ball has a velocity of 23 m s^{-1} in a horizontal direction. After hitting the wall the ball moves with a velocity of 18 m s^{-1} in the opposite direction. Determine the impulse provided by the wall? [2]

4 A ball falls vertically on to a horizontal surface. The momentum of the ball just before it hits the surface is *p*.



The ball collides inelastically with the surface and rebounds from it.

What is a possible value for the magnitude of the change in momentum of the ball from just before until just after contact with the surface? [N17P1Q5]

A 0.5 *p* **B** 1.0 *p* **C** 1.5 *p* **D** 2.0 *p*

5 An empty conveyor belt requires a constant force of 17.0 N to be driven horizontally at 1.50 m s^{-1}. Sand is then vertically dropped at a rate of 3.00 kg s^{-1} onto the conveyor belt.

Determine the total average force required to be exerted on the conveyor belt In order to maintain the conveyor belt at the speed of 1.50 m s^{-1} while the sand is being poured? [2]

6 An object of mass *M* travelling to the right with velocity *u* collides with another object of mass *M* travelling to the left with velocity 2*u*. After the collision, the two objects stick together.

Determine the magnitude of the final velocity in terms of *u* and states its direction? [2]

7 Does the principle of conservation of momentum apply in cases where two colliding bodies lose kinetic energy as a result of sticking to one another at the point of collision? Explain your answer with reference to Newton's third law. [2]

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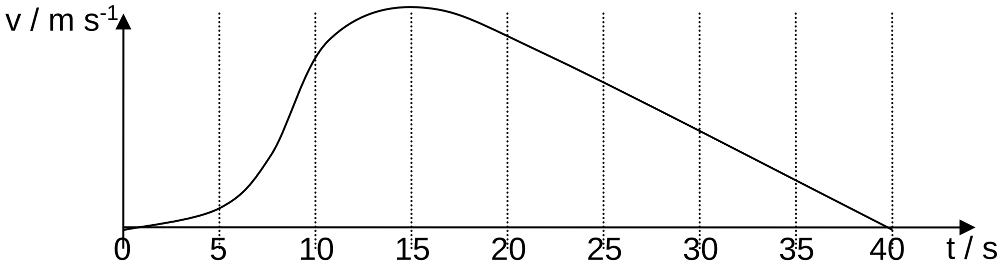
8 A small rocket with a total initial mass 25 kg is launched. The fuel is initially burned at a steady rate of 1.5 kg s^{-1} and the products of combustion are ejected at a constant rate of 200 m s^{-1}.

As the fuel is burning steadily, the rocket climbs up vertically with an increasing acceleration. However, before it completely runs out of fuel, the rate of burning decreases from 1.0 kg s^{-1} to zero over an interval of time. Assuming that acceleration due to gravity is constant and neglecting air resistance, the graph below shows how the upward speed of the rocket varies with time after the rocket takes off.



(i) State Newton's second law of motion. [2]

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(ii) State, with a reason, the time when no resultant force acts on the rocket. [2]

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(iii) State, with a reason, the time at which the fuel burns out. [2]

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(iv) Suggest how it is possible for the acceleration to increase while the fuel is burning at a constant rate. [2]

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Dynamics Quiz Solutions

1 Answer: **D**. F_E and F_S are action-reaction pair. Hence they are equal in magnitude and opposite in direction. Since they act on different bodies, they do not cancel each other out. [1]

2 Since there was no acceleration, the weight = normal reaction from the lift's floor = mg = 589 N [1]

3 Taking towards the wall as the positive direction,
Impulse by the wall = m(v-u)
= 0.08 (-18-23) [1]
= -3.3 Ns
The impulse is <u>3.3 Ns away from the wall</u>. [1]

4 Answer: **C.** Let the rebound momentum be p'.
The change in momentum = final – initial momentum.
Taking direction of final momentum p' to be positive, $\Delta p = p' - (-p) < 2p$
since p' < p for inelastic collision

Answer can be any value from > p to < 2p.

5 Upon landing on belt, the sand is accelerated **horizontally** from 0 m s^{-1} to 1.50 m s^{-1}

The mass is changing at a rate $\frac{dm}{dt}$ = 3.00 kg per second.

Thus the rate of change of momentum of the sand = **$v\frac{dm}{dt}$ = (1.5)x 3 = 4.5 N** **[1]**

The total force required = 4.5 **+ 17** = 21.5 N. [1]

(Note that the force that causes the change in momentum of the sand is the **<u>frictional force between the sand particles and the belt</u>**)

6 Let the velocity of the 2 objects after collision be *v*.

$$\Rightarrow \quad Mu + M(-2u) = 2Mv \quad [1]$$

$$-Mu = 2Mv$$

$$Mv = -\frac{1}{2}Mu$$

$$v = -\frac{1}{2}u \quad [1]$$

The final velocity has a magnitude of of ½ u and is towards the left.

7 According to Newton's third law, the two bodies exert <u>equal and opposite forces</u> on each other. [1]
Hence <u>the impulse</u> (or change in momentum) of body A will be <u>equal but opposite to</u> that of body B.[1]
Taken as a whole system, the total momentum of the colliding bodies remains unchanged, and the principle applies.

8 **(i)** The rate of change of momentum of a body is <u>proportional to the net force</u> acting on it, and this (rate of) change of momentum takes place <u>in the direction of the net force</u>. [1] [1]

(ii) Time = <u>15 s</u>. Acceleration = 0 m s^{-2} . <u>When there is no resultant force, there is no acceleration, hence gradient of v-t graph is zero.</u> [1] [1]

(iii) Time = <u>20 s</u>. [1]
<u>After</u> this time, <u>acceleration is constant and negative.</u> [1]

(iv) The <u>weight</u> of the rocket <u>decreases</u> as fuel is spent. [1]

Thus the <u>resultant force increases</u>, causing the acceleration to increase, according to Newton's 2nd law. [1]

Note: Although F = m a, F is NOT constant. F = thrust – weight, and weight is decreasing with time, so F is increasing. Therefore, acceleration increases because m is decreasing AND F is INCREASING