Practice SL TEST: Mechanics Paper 2	Name: Coop

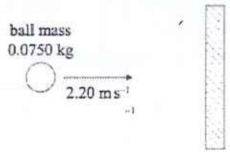
1.

A2. This question is about impulse.

(a) A net force of magnitude F acts on a body. Define the *impulse* I of the force. *[1]*

Force on object × time interval

(b) A ball of mass 0.0750 kg is travelling horizontally with a speed of 2.20 m s^{-1}. It strikes a vertical wall and rebounds horizontally.



Due to the collision with the wall, 20 % of the ball's initial kinetic energy is dissipated.

(i) Show that the ball rebounds from the wall with a speed of 1.97 m s^{-1}. *[2]*

$KE_f = .80\ KE_o$

$\frac{1}{2} m v_f^2 = .80\ \frac{1}{2} m v_o^2 \quad v_f^2 = .80(2.20)^2$

$v_f = 1.97$ m/s opposite direction

(ii) Show that the impulse given to the ball by the wall is 0.313 N s. *[2]*

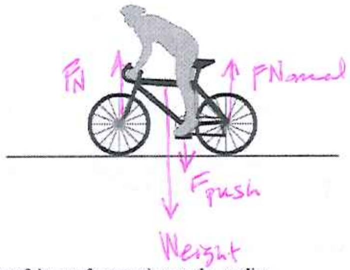
$F\Delta t = m\Delta v = (.0750\ kg)(-1.97 - 2.20\ m/s)$

$F\Delta t = .313$ N·s

2.

Part 2 Force and energies

(a) A system consists of a bicycle and cyclist travelling at a constant velocity along a horizontal road.



(i) State the value of the net force acting on the cyclist. *[1]*

0

(ii) On the diagram draw labelled arrows to represent the vertical forces acting on the bicycle. *[2]*

(iii) With reference to the horizontal forces acting on the system, explain why the system is travelling at constant velocity. *[2]*

forward F = Force of friction

$\Sigma F = 0$ so $a = 0$

Suvat!

(b) The total resistive force acting on the system is 40 N and its speed is $8.0\,m\,s^{-1}$. Calculate the useful power output of the cyclist. *[1]*

$P = F \cdot v = 40N \times 8.0\frac{m}{s} = 320W$

(c) The cyclist stops pedalling and the system comes to rest. The total mass of the system is 70 kg.

(i) Calculate the magnitude of the initial acceleration of the system. *[2]*

$\Sigma F = ma \quad a = \frac{\Sigma F}{m} = \frac{40N}{70kg} = -0.57\frac{m}{s^2}$

(ii) Estimate the distance taken by the system to come to rest from the time the cyclist stops pedalling. *[2]*

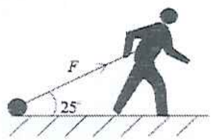
$v^2 = u^2 + 2as$

$s = \frac{v^2 - u^2}{2a} = \frac{0 - 8^2}{2(-0.6)} = 56m$

3.

A2. This question is about forces.

An athlete trains by dragging a heavy load across a rough horizontal surface.



The athlete exerts a force of magnitude F on the load at an angle of 25° to the horizontal.

(a) Once the load is moving at a steady speed, the average horizontal frictional force acting on the load is 470 N.

Calculate the average value of F that will enable the load to move at constant speed. *[2]*

$F\cos(25°) = 470$

$F = 518 = 520N$

(b) The load is moved a horizontal distance of 2.5 km in 1.2 hours.

Calculate

(i) the work done on the load by the force F. *[2]* $W = F \cdot d$, 1175000

$= 470 \times 2500m = 1.2MJ$ ← rounded

(ii) the minimum average power required to move the load. *[2]*

$P = \frac{W}{t} = \frac{1.2MJ}{1.2hr \times 3600s} = 278W$

(c) The athlete pulls the load uphill at the same speed as in part (a).

Explain, in terms of energy changes, why the minimum average power required is greater than in (b)(ii). *[2]*

air resistance / friction

work is done raising the load vertically

4.

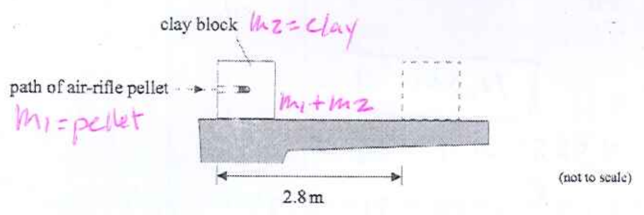
Part 2 Collisions

(a) State the principle of conservation of momentum. *[2]*

total momentum of a system stays constant

system must be isolated (no external forces)

(b) In an experiment, an air-rifle pellet is fired into a block of modelling clay that rests on a table.



The air-rifle pellet remains inside the clay block after the impact.

As a result of the collision, the clay block slides along the table in a straight line and comes to rest. Further data relating to the experiment are given below.

Mass of air-rifle pellet	= 2.0 g = .002 kg
Mass of clay block	= 56 g = .056 kg
Velocity of impact of air-rifle pellet	= 140 m s^{-1}
Stopping distance of clay block	= 2.8 m

(.002 kg + .056 kg) = .058 kg

(i) Show that the initial speed of the clay block after the air-rifle pellet strikes it is 4.8 m s^{-1}. [2]

$m_1 v_1 + m_2 v_2 = (m_1 + m_2) V_f$ (both)

$(.002)(140) = (.058) V_f$

$V_f = 4.8 \text{ m/s}$

(ii) Calculate the average frictional force that the surface of the table exerts on the clay block whilst the clay block is moving. [4]

$W = \Delta KE = F \cdot d$

$F = \frac{\Delta KE}{d} = \frac{\frac{1}{2} m v^2}{2.8 \text{ m}} = \frac{\frac{1}{2}(.058)(4.8)^2}{2.8}$

$F = 0.24 \text{ N}$

* Can use suvat as well

$v^2 = u^2 + 2as$

$a = \frac{v^2 - u^2}{2s} = \frac{0 - (4.8)^2}{2(2.8)} = -4.11 \text{ m/s}^2$

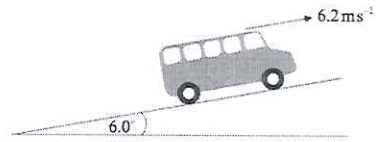
$F_f = ma = (.058 \text{ kg})(-4.11 \text{ m/s}^2)$

$F_f = -0.24$ [illegible]

5.

Part 1 Power and efficiency

A bus is travelling at a constant speed of 6.2 m s^{-1} along a section of road that is inclined at an angle of 6.0° to the horizontal.



a.

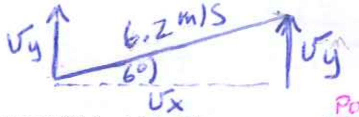
(ii) State the value of the rate of change of momentum of the bus. [1]

0 (no Δv = no Δp)

(b) The total output power of the engine of the bus is 70 kW and the efficiency of the engine is 35%. Calculate the input power to the engine. [2]

$Eff = \frac{P_{out}}{P_{in}}$ $\quad P_{in} = \frac{P_{out}}{Eff} = \frac{70 \text{ kW}}{.35}$

$P_{in} = 200 \text{ kW}$



(c) The mass of the bus is 8.5×10^3 kg. Determine the rate of increase of gravitational potential energy of the bus. [3]

Power

$v_y = 6.2\ m/s \cdot \sin(6°) = 0.65\ m/s$

$Power = \frac{\Delta PE}{time} = \frac{mgh}{t} = mgv_y$

$Power = (8.5\times10^3\ kg)(9.8\ m/s^2)(0.65\ m/s)$

$P = 54{,}000\ W = 54\ kW$

(d) Using your answer to (c) and the data in (b), estimate the magnitude of the resistive forces acting on the bus. [3]

Power to beat friction = P_{output} − Power up

$= 70\ kW - 54\ kW = 16\ kW$

$P = F \cdot v \qquad F = \frac{P}{v} = \frac{16000\ W}{6.2\ m/s} \approx 2.6\times10^3\ N$

2581 N

(e) The engine of the bus suddenly stops working.

(i) Determine the magnitude of the net force opposing the motion of the bus at the instant at which the engine stops. [2]

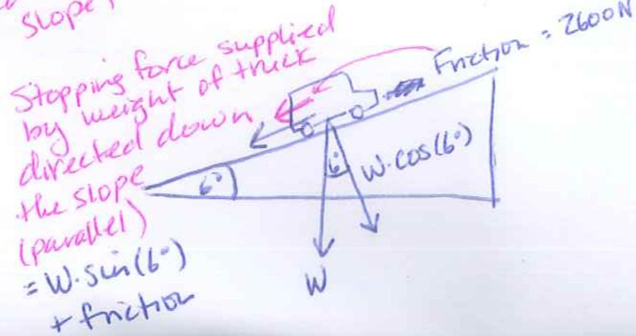
see below

$W \cdot \sin(6°) = (8.5\times10^3\ kg)(9.8\ m/s^2)(\sin 6°)$

$= 2600\ N + 8885\ N$

$= 11{,}485\ N$

At this moment, friction is still resisting upward motion (directed down slope)

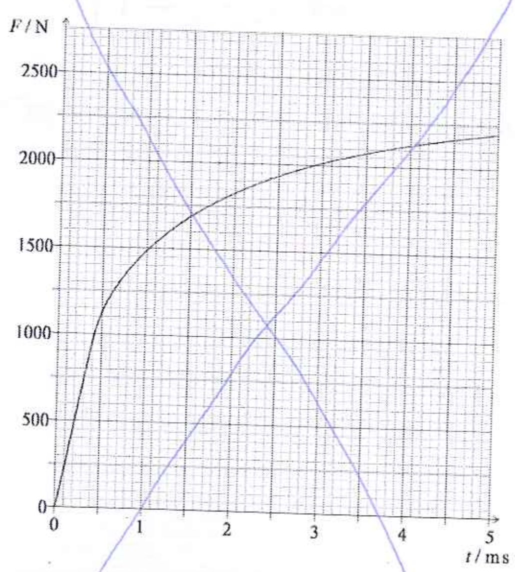


Extra problems taken out.

5.

Part 1 Dynamics and energy

A bullet of mass 32 g is fired from a gun. The graph shows the variation of the force F on the bullet with time t as it travels along the barrel of the gun.



The bullet is fired at time $t=0$ and the length of the barrel is 0.70 m.