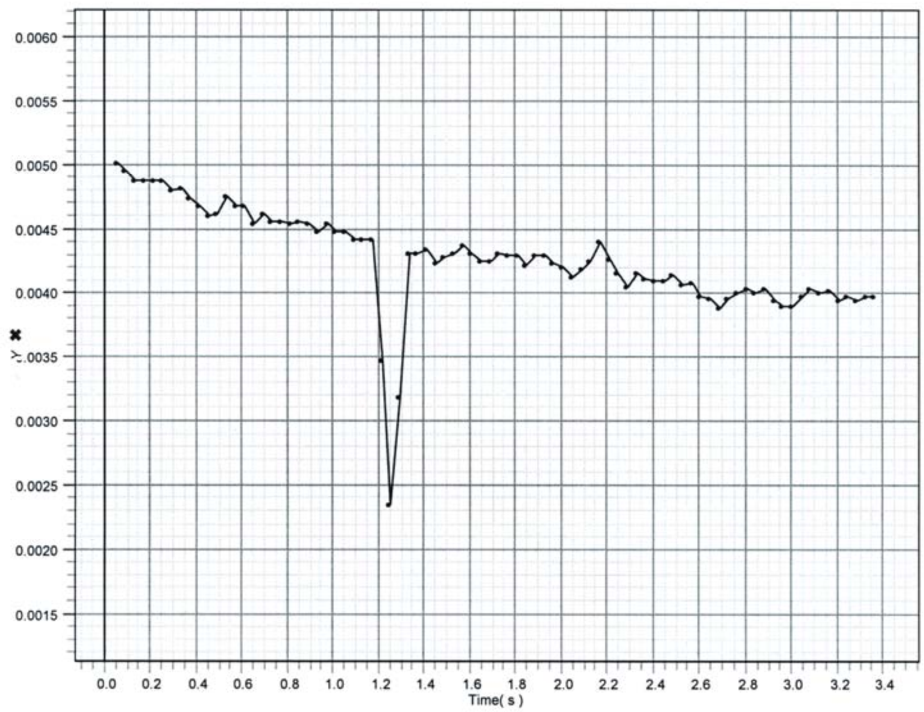
SOLUTIONS TO ASSIGNMENT 1 2005

1 a) **Glider 1 which is initially travelling at almost constant velocity collides with glider 2 which is initially at rest. Since the two gliders are of approximately the same mass, after the collision glider 1 is at rest and glider 2 moves off with the same velocity that glider 1 had before the collision. The reason why the two velocities have different signs is that the motion sensors are at the opposite ends of the track and glider 1 is initially moving away from its sensor (positive velocity) and after the collision, glider 2 is moving toward its sensor (negative velocity). There is a little air resistance or "friction" and so the velocity decreases slightly from the beginning to the end of the run.**

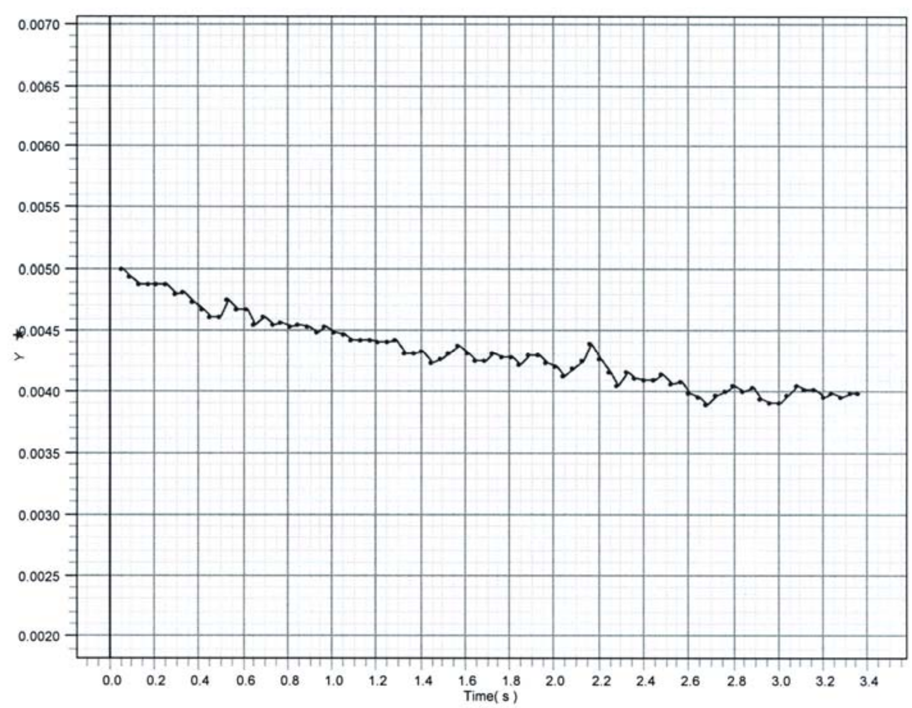
1 b)



1 c) **The kinetic energy is the same immediately before and after the collision and so the collision must be elastic.**

1 d) **The kinetic energy is not conserved during the collision which takes place over about 0.15 seconds. The kinetic energy clearly decreases when some of the energy goes into potential energy of the "bumpers" of the gliders.**

1 e)



3) **The error in the average time is 0.2 ms which is the accuracy of the timer. Note that in this situation the precision may be high but the accuracy is lower, i.e. there may be a systematic error due to the timer.**

4 a) **The motion must be simple harmonic motion since the second derivative of the function is proportional to the original function plus a constant. As a solution try:** $x = A\sin(\omega t + \varphi) + B$.

When t = 0, v = 0 so this means that the sine function takes on its largest value and so $\varphi = \frac{\pi}{2}$.

The time to complete one cycle is π seconds and therefore T = π.

$$\omega = 2\pi f = \frac{2\pi}{T} = \frac{2\pi}{\pi} = 2$$

In one cycle it has traveled 4A = 12 meters and therefore A = 3.

Since A = 3 and x = 5 when t = 0 then 5 = 3 + B and therefore B = 2.

So the solution is $x = 3\sin(2t + \frac{\pi}{2}) + 2$

4 b) **By analogy with** $\omega = \sqrt{\frac{k}{m}}$, $\omega = \sqrt{Q}$ **and since** $\omega = 2$ **then** $2 = \sqrt{Q}$ **or** $Q = 4$.

4 c) $x = 3\sin(2t + \frac{\pi}{2}) + 2 \quad (1)$

$$\frac{dx}{dt} = 6\cos(2t + \tfrac{\pi}{2})$$

$$\frac{d^2x}{dt^2} = -12\sin(2t + \tfrac{\pi}{2}) \quad (2)$$

Putting (1) and (2) into $\frac{d^2x}{dt^2} = -Qx + R$

$$-12\sin(2t + \tfrac{\pi}{2}) = -4\left[3\sin(2t + \tfrac{\pi}{2}) + 2\right] + R$$

$-12\sin(2t + \frac{\pi}{2}) = -12\sin(2t + \frac{\pi}{2}) - 8 + R$ **and this will only be true when R = +8.**

5 a) $v_{max} = \omega A$ **and so** $A = \frac{v_{max}}{\omega} = \frac{v}{\omega}$

5b) $y = -A\sin(\omega t) = -\left(\frac{v}{\omega}\right)\sin(\omega t)$