1. A block of mass 10 kg is pulled along a straight horizontal road by a constant horizontal force of magnitude 70 N in the direction of the road. The block moves in a straight line passing through two points A and B on the road, where $AB = 50$ m. The block is modelled as a particle and the road is modelled as a rough plane. The coefficient of friction between the block and the road is $\frac{4}{7}$

(a) Calculate the work done against friction in moving the block from A to B.

(4)

The block passes through A with a speed of 2 m s^{-1}.

(b) Find the speed of the block at B.

(4)

(Total 8 marks)

2. A particle P of mass 0.5 kg is moving under the action of a single force **F** newtons. At time t seconds, $\mathbf{F} = (1.5t^2 - 3)\mathbf{i} + 2t\mathbf{j}$. When $t = 2$, the velocity of P is $(-4\mathbf{i} + 5\mathbf{j})$ m s^{-1}.

(a) Find the acceleration of P at time t seconds.

(2)

(b) Show that, when $t = 3$, the velocity of P is $(9\mathbf{i} + 15\mathbf{j})$ m s^{-1}.

(5)

When $t = 3$, the particle P receives an impulse **Q** N s. Immediately after the impulse the velocity of P is $(-3\mathbf{i} + 20\mathbf{j})$ m s^{-1}. Find

(c) the magnitude of **Q**,

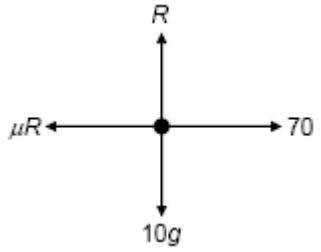
(3)

(d) the angle between **Q** and **i**.

(3)

(Total 13 marks)

1. (a)



$R(\updownarrow): R = 10g$ B1

$F = \mu R \Rightarrow F = \frac{4}{7}(10g) = 56$ B1

$\therefore$ WD against friction $= \frac{4}{7}(10g)(50)$ M1

2800(J) A1 4

(b) 70(50) – "2800" = $\frac{1}{2}(10)v^2 - \frac{1}{2}(10)(2)^2$ M1 *

A1ft

$700 = 5v^2 - 20$, $5v^2 = 720 \Rightarrow v^2 = 144$ d * M1

Hence, $v = \underline{12}$ (m s^{-1}) A1 cao 4

Or N2L $(\rightarrow): 70 - \frac{4}{7}R = 10a$ M1 *

$70 - \frac{4}{7} \times 10g = 10a, (a = 1.4)$ A1ft

AB $(\rightarrow)$: $v^2 = (2)^2 + 2(1.4)(50)$ d * M1

Hence, $v = \underline{12}$ (m s^{-1}) A1 cao 4

[8]

2. (a) N2L $(1.5t^2 - 3)\mathbf{i} + 2t\mathbf{j} = 0.5\mathbf{a}$ Ml

$\mathbf{a} = (3t^2 - 6)\mathbf{i} + 4t\mathbf{j}$ Al 2

(b) $\mathbf{v} = (t^3 - 6t)\mathbf{i} + 2t^2\mathbf{j}$ (+c) Ml Al

$t = 2$ $-4\mathbf{i} + 5\mathbf{j} = -4\mathbf{i} + 8\mathbf{j} + \mathbf{c}$ (c = –3j) Ml

$\mathbf{v} = (t^3 - 6t)\mathbf{i} - (2t^2 - 3)\mathbf{j}$ (m s^{-1}) Al

$t = 3$ $\mathbf{v} = 9\mathbf{i} + 15\mathbf{j}$ (m s^{-1}) * cso Al 5

(c) $\mathbf{Q} = 0.5(-3\mathbf{i} + 20\mathbf{j} - (9\mathbf{i} + 15\mathbf{j}))$ (=0.5(–12**i** + 5**j**)) Ml

$|\mathbf{Q}| = 0.5\sqrt{(5^2 + 12^2)} = 6.5$ Ml Al 3

(d) acute angle is $\arctan\frac{5}{12} \approx 23°$ M1A1

or required angle is $\arctan\frac{-5}{12}$

or acute angle is $\arccos\frac{12}{13} \approx 23°$

or required angle is $\arccos\frac{-12}{13}$

required angle is 157° awrt 157°, 203° Al 3

[13]

1. Few candidates had problems finding the frictional force in part (a), but once again many candidates were insecure about finding work done. Many candidates found the net work done by the horizontal force and against friction, rather than simply the work done against friction.

As usual the most popular approach in part (b) was to find the acceleration of the block and then the velocity after 50 m using $v^2 = u^2 + 2as$. A significant proportion of candidates who attempted to use the work-energy principle missed one or more terms. However, many of those candidates who misinterpreted part (a) were able to use their nett work done successfully to find v using this method.

2. Candidates were confident in their solutions to this question with many scoring all but the last mark. It was pleasing to see much competent use of calculus and vector mechanics. Only a few failed to include a constant in working towards the given solution for (b). It was disappointing to find candidates with an incorrect answer in (b) attempting to fudge the given answer rather than look for the error in their working. Attempts to find the impulse $\boldsymbol{Q}$ were usually correct, but several candidates with a correct $\boldsymbol{Q}$ did not go on to find the magnitude. Errors in $\boldsymbol{Q}$ were often due to arithmetic errors in the subtraction, but some candidates did omit the mass. In (d), many candidates failed to score the final mark. There appeared to be little appreciation of the actual angle required, even from some candidates who had drawn a correct diagram.