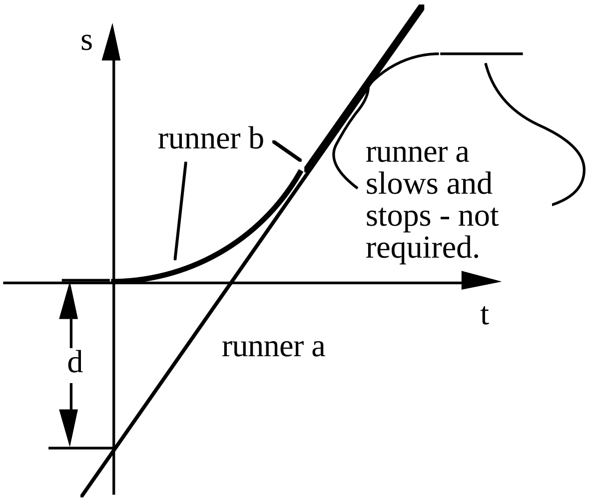
Marking scheme for preliminary test

Question 1



This explanation not required: just the graphs, and the deceleration phase is not required.

Runner b starts at (t,s) = (0,0). She accelerates from rest, so her graph is a parabola, initially with slope zero, and finally with slop v. She then continues with constant v: a straight line on the s(t) graph. In this phase, her position is the same as that of runner a, so their s(t) are identical for a straight line segment (during which the baton is passed).

(Runner a then decelerates (a parabola with negative acceleration) until her velocity is zero (s(t) horizontal).

4 marks for a clear diagram

iii) Runner a has displacement $s_a = vt - d$ ✓

v) Runner b has displacement $s_b = \frac{1}{2}at^2$ during acceleration phase ✓

vi) Runner b accelerates at a from rest to final speed v in time T where v = aT, so T = v/a = 4 s. ✓

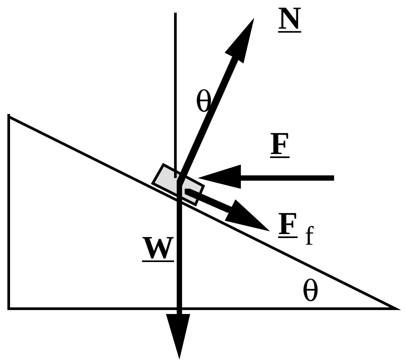
vii) at t = T, $s_b = s_a$ $\frac{1}{2}aT^2 = vT - d$ ✓

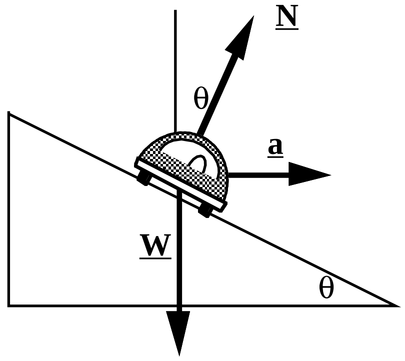
$d = vT - \frac{1}{2}aT^2$ ✓

$= vT - \frac{1}{2}aT^2 = v^2/a - \frac{1}{2}v^2/a = \frac{1}{2}v^2/a$ ✓ ✓

$d = 16$ m. ✓

Question 2 (14 marks)





i) No acceleration so Σforces = 0. Resolve forces in the directions normal to and in the plane.

In the normal: $N = W\cos\theta + F\sin\theta$

In the plane $F\cos\theta = W\sin\theta + F_f$

$$F\cos\theta = W\sin\theta + \mu_k N$$

Eliminate N:

$$F\cos\theta = W\sin\theta + \mu_k(W\cos\theta + F\sin\theta)$$

$$F(\cos\theta - \mu_k\sin\theta) = W(\sin\theta + \mu_k\cos\theta)$$

$$F = mg\frac{\sin\theta + \mu_k\cos\theta}{\cos\theta - \mu_k\sin\theta}$$

ii) Let **ds** be the displacement up the plane:

$$\text{Power} = \frac{d(\text{work})}{dt} = \frac{\mathbf{F}\cdot\mathbf{ds}}{dt}$$

$$= \frac{F\cos\theta\, ds}{dt} = Fv\cos\theta$$

iii) If there is no friction force in the plane of the diagram, then the horizontal acceleration **a** satisfies

$$ma = N\sin\theta$$

There is no vertical acceleration so

$$W = N\cos\theta$$

and the centripetal acceleration required is v^2/R, so

$$m\frac{v^2}{R} = N\sin\theta = \frac{W}{\cos\theta}\sin\theta = mg\tan\theta$$

$$\theta = \tan^{-1}\left(\frac{v^2}{Rg}\right)$$